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ORIGINAL ARTICLES.

I.—Subaërial Deposits of the Arid Region of North America.

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Part I.

Introduction.

THE subaërial deposits now accumulating in the arid portion of the United States may be divided into four classes: 1, Eolian Sands; 2, Talus Slopes; 3, Alluvial Cones; and 4, Calcareous Clays to which no specific name has been applied, but which, for reasons stated below, will be called "adobe" in this paper.

Eolian Sands.—Rounded hills of blown sands termed dunes give variety to the landscape in many portions of the arid region. These are local accumulations, but they sometimes have an extent of many square miles, and may attain a thickness of several hundred feet. They occur most frequently in sheltered valleys or in bay-like recesses of large valleys, where topographic conditions favoured the accumulation of wind-borne particles. They are usually composed of quartz grains, which show by their rounded and worn appearance, when examined under the microscope, that they have travelled far during their uncertain wanderings. Dunes are constantly changing their forms, each wind that blows being busy in remodelling the contours of their rounded domes. Their internal structure is extremely irregular, frequently showing cross-bedding and intricate contortions. Their surfaces are wind-rippled and many times covered with footprints.

In some instances, especially on the Carson Desert, Nev., small-sized dunes may be seen which are formed of the cases of minute Crustaceans (*Cypris*) which have been gathered by the wind from the surface of the desert and accumulated in piles in the same manner as in the formation of ordinary sand dunes.

Near Fillmore, Utah, another exceptional variety of dunes occurs, formed of small crystals of gypsum, which have been swept from a neighbouring desiccated lake-basin and accumulated in conspicuous white hills.

The dunes of arid regions have the same characteristic forms as those occurring in more humid climates. They are steep on the leeward side and slope much more gently in the direction from which the prevailing winds blow. The sources from which they

are supplied are usually less easily determined, however, than in the case of sand hills which accumulate along the borders of oceans, lakes and rivers.

Talus Slopes.—These occur in abundance at the bases of nearly all rock escarpments, and are usually composed of coarse angular material. They owe their accumulation to the falling of detached blocks from the faces of rocky cliffs. Their surface slopes are usually high, depending on the angle of stability of the material of which they are composed, and are much greater than the corresponding slopes of alluvial cones, next to be described. Unlike alluvial cones, too, they occur quite uniformly along the bases of steep mountains instead of being confined to the mouths of cañons.

The talus slopes of arid regions are of essentially the same character as those occurring in humid climates, and farther notice of them at this time seems unnecessary.

Alluvial Cones.—The smooth, even slopes of these deposits are a noticeable feature about the bases of all the principal mountains in the Far West. They are formed of both coarse and fine material which has been swept out of gorges in the mountains and deposited in the valleys. In many instances they have a great superficial extent, and where the conditions for their formation are most favourable, may be hundreds and possibly thousands of feet in thickness.

The alluvial cones of the region of interior drainage in the western part of the United States, known as the Great Basin, have been described by Mr. G. K. Gilbert,[1] and we cannot do better than quote his description :—

"The sculpture of a mountain by rain is a twofold process; on the one hand destructive, on the other constructive. The upper parts are eaten away in gorges and amphitheatres until the intervening remnants are reduced to sharp-edged spurs and crests, and all the detritus thus produced is swept outward and downward by the flowing waters, and deposited beyond the mouths of the mountain gorges. A large share of it remains at the foot of the mountain mass, being built into a smooth sloping pediment. If the outward flow of the water were equal in all directions, this pediment would be uniform upon all sides; but there is a principle of concentration involved, whereby rill joins with rill, creek with creek, and gorge with gorge, so that when the water leaves the margin of the rocky mass, it is always united into a comparatively small number of streams, and it is by these that the entire volume of detritus is discharged. About the mouth of each gorge a symmetric heap of alluvium is produced—a conical mass of low slope, descending equally in all directions from the point of issue; and the base of each mountain exhibits a series of such alluvial cones, each with its apex at the mouth of a gorge, and with its broad base resting upon the adjacent plain or valley. Rarely these cones stand so far apart as to be completely individual and distinct, but usually the parent gorges are so thickly set along the mountain front that the

[1] Contributions to the History of Lake Bonneville, in Second Ann. Rept. U. S. Geol. Surv. 1880–81, p. 183.

cones are more or less united and give to the contours of the mountain base a scalloped outline."

Alluvial cones when best developed extend out from the mountains to a distance in many instances of several miles. Not infrequently the deposits on opposite sides of the valley unite along the centre of the depression, so that its profile is an unbroken curve; or, more accurately, is a combination of two curves, for each alluvial cone has a concave surface.

The material forming alluvial cones varies in size from the finest powder to angular rock weighing many tons. It exhibits no regular bedding or stratification, but coarse and fine debris are mingled in endless variety. There is a well-marked gradation, however, to be seen as one travels from the apex of an alluvial cone towards its periphery. At the apex it is composed mostly of coarse, angular material, with fine silt-like clays filling the interspaces. Toward the periphery the fine material predominates, and in many instances forms a homogeneous unstratified deposit, without stones or pebbles. At other times coarse material occurs at certain horizons in the fine silt, thus recording periods of unusual precipitation, when the gravels from the mountains were swept out into the valleys to a greater distance than under ordinary conditions. At the lowest limits to which the debris is carried in large valleys it is always fine, and has a much smaller surface slope than the upper portions of the alluvial cones with which it is associated.

The climatic conditions favouring the formation of alluvial cones might be discussed; but as deposits of this nature are not the special subject of this paper, their further consideration will be postponed.

Calcareous Clays (*Adobe*).—Widely distributed throughout the valleys of the more arid portion of the United States there occurs a peculiar calcareous clay which is used largely by the Indians, Mexicans and others for the manufacture of sun-dried bricks, known by the Spanish name "adobe." The earth from which these bricks are made is also designated by the same name. We have therefore adopted it, with some extension of its popular meaning, as a convenient term by which to designate the fine subaërial accumulations in general, exclusive of eolian sands, which occur in the region just referred to.

I.—Adobe.

Distribution.—The area over which adobe forms a large part of the surface has not been accurately mapped, but enough is known to indicate that it is essentially co-extensive with the more arid portions of this country. In a very general way it may be considered as being limited to the region in which the mean annual rainfall is less than twenty inches. It forms the surface over large portions of Colorado, New Mexico, Western Texas, Arizona, Southern California, Nevada, Utah, Southern Oregon, Southern Idaho, and Wyoming. In this paper the great area here designated is termed the Arid Region. Adobe occurs also in Mexico and may there reach a greater development than in the United States, but observations concerning it south of the Rio Grande are wanting.

In the United States it occurs from near the sea-level in Arizona, and even below sea-level in Southern California, up to an elevation of at least six or eight thousand feet, along the eastern border of the Rocky Mountains, and in the elevated valleys of New Mexico, Colorado and Wyoming. It occupies depressions of all sizes up to valleys having an area of hundreds of square miles. Although occurring throughout the Arid Region, it can be studied to best advantage in the drainless and lakeless basins at Nevada, Utah, and Arizona.

Thickness.—The maximum thickness of the adobe is always difficult to determine, for the reason that it is still accumulating, and has not been sufficiently dissected by erosion to expose sections of any considerable depth. That it not infrequently has a depth of many hundreds of feet is apparent to one who traverses the valley in which it occurs. The profiles of very many of these valleys indicate that they have probably been filled to a depth of at least two or three thousand feet. In the larger valleys there are rocky crests, called "lost mountains," which project above the broad level desert surface, and are in reality the summits of precipitous mountains that have been almost completely buried beneath recent accumulations. These qualitative observations are supported by a few quantitative measurements.

At Sandy, about six miles south of Salt Lake City, Utah, and at a distance of two or three miles west of the west base of the Wasatch Mountains, a well was bored a few years since, in search of artesian water, which penetrated fine yellow earth with occasional layers of sand, gravel and clay, to a depth of about 1500 feet, without reaching the rock-bottom of the basin. The material taken from near the bottom of this well was of the same character as that occurring at the surface over a large number of valleys throughout the Arid Region.

The boring at Sandy is in the basin of Lake Bonneville (Quaternary), but the entire depth of material penetrated cannot be referred to the deposits of that lake. Older lakes, in which sands and clays must have been accumulated, probably existed in the same basin in pre-Bonneville times, and the depression must also have been filled by purely subaërial deposits. It is impossible to determine whether the comminuted material brought up from the well was deposited under water or not, but the precise manner in which its accumulation took place does not concern us so much at present as the evidence which the well affords of the great depth of superficial material occurring in Great Salt Lake Valley, and, it is to be presumed, in adjacent valleys as well.

A second well over 1300 feet deep was bored a few years since near Humboldt Lake, Nev., which penetrated material of the same general character as that brought up from the well near Salt Lake City, and, as in the former instance, did not reach the true rock-bottom of the basin in which it was bored. This well was located in a valley once occupied by the waters of Lake Lahontan (Quaternary), but only the extreme upper portion of the material penetrated can be referred to the sediment of that lake.

A large number of wells have been bored in the Great Valley of California, which penetrate alternating layers of unconsolidated sand, gravel and clay, to depths varying from a few hundred to 2300 feet without reaching bed rock.[1] The deepest of these is situated in the northern part of the San Joaquin Valley, as I have been informed by Wm. Ham. Hall, State Engineer of California.

With these measurements before us, it does not seem that an estimate of three thousand feet or more, for the thickness of the superficial deposits in many of the valleys of the Arid Region, is too great. My confidence in this conclusion has been increased by finding that the depth of superficial material in the valley of Great Salt Lake has been estimated by G. K. Gilbert[2] at 5000 or 6000 feet.

Physical Characters.—Typical examples of adobe may be seen in thousands of places in the Arid Region, where sun-dried bricks are being made. In every Indian and Mexican village of Arizona and New Mexico there are excavations where material has been obtained for this purpose. Many times the bricks used in the construction of a building are made from the earth removed in digging its foundations. At these and many other localities where the adobe is open to view, it appears as a fine-grained porous earth, varying in colour through many shades of grey and yellow, which crumbles between the fingers, but separates most readily in a vertical direction. The coherency of the material is so great that vertical scarps will stand for many years without forming a noticeable talus slope. The sun-dried bricks made from it are more durable than the escarpments of natural earth, and when built into walls are capable of standing the atmospheric conditions to which they are subjected for scores of years. There are buildings now in use in Santa Fé, N.M., built of sun-dried bricks, which, I have been assured on good authority, have been standing for more than a century.

Adobe is frequently exposed in the sides of arroyos or dry water-courses, especially in the valleys along the eastern base of the Rocky Mountains from Wyoming to Mexico. At Cañon City, Colorado, exposures of this character are abundant, and sections from fifteen to twenty feet in height may be examined in detail. Wells dug in the same region have penetrated the adobe to a depth of forty feet without reaching its lower limit. At these and at numerous other localities that have been examined no lines of stratification could be distinguished, but the deposits were homogeneous throughout, except at times when lines of pebbles marked more or less definite horizons. Pebbles are most abundant near the mountains, and become less and less frequent as one recedes from them. At a few localities the adobe was seen to be traversed by small vertical tubes, some of which branched downward. In samples collected at Santa Fé, N.M., the tubes have a diameter ranging from a fiftieth to a hundredth of

[1] Physical Data and Statistics of California, Sacramento, 1886.

[2] Report on the Geology of Portions of Nevada, Utah, California and Arizona, in Report of Geographical and Geological Explorations and Surveys West of the 100th Meridian, Washington, 1875, vol. iii. p. 66.

an inch. In no instance could a definite lining to the tubes be distinguished.

The adobe used for brick-making is usually light grey in colour, but this is not always the case. It is frequently light yellow, and has varying tints according to locality. Sometimes it has a reddish tint, caused by the prevailing colour of the surrounding rocks from which it was in large part derived. The grey colour of the adobe commonly seen in buildings is due in many, and probably in all cases, to an admixture of organic matter. Its characteristic colour, when free from organic matter, is light yellow. In alluvial cones, and generally throughout the drainless valleys of the Arid Region, this is the prevailing tint. The organic matter which darkens the adobe in many instances may have been contained in the rocks from which it was derived; this is certainly the case near Cañon City, Col., where the adobe is formed principally from the wash of grey Jurassic shales. At other times the colour seems to have originated from the decay of vegetable matter buried in the deposit.

When examined under the microscope, the adobe is seen to be composed of irregular, unassorted flakes and grains, principally quartz, but fragments of other minerals are also present. An exhaustive microscopic study has not been made, but the samples examined from widely-separated localites were very similar. The principal characteristics observed were the extreme angularity of the particles composing the deposit and the undecomposed condition of the various minerals entering into its composition. It is to be inferred from this that the material was not exposed even to a very moderate degree of friction, and had not undergone subaërial decay before being deposited. Adobe collected at typical localities is so fine in texture that no grit can be felt when it is rubbed between the fingers; in other instances it contains angular rock fragments of appreciable size, and, as we have stated in speaking of alluvial cones, may be intimately associated with rock-masses many tons in weight. When the rocks overlooking adobe-filled valleys are of easily eroded sandstone, the deposit in the valley below is sometimes so sandy that the distinctive features of adobe are lost. Other changes in colour and texture have been observed, depending on the character of the rocks from which the deposit was derived.

Chemical Characters.—Analyses of several samples of adobe are given in the following table, which show that it not only has a varied composition, but differs in its chemical characteristics in different localities.

The diversity of composition, as shown in the table, indicates that the deposits which we have classed under the same name on account of their physical and other characteristics vary widely in constituents. These analyses show that adobe is very distinct from residual clays, as is also proven by its appearance under the microscope. The table of analyses of residual clays from the Southern Appalachian region is here introduced for convenience of comparison. Residual clays are composed essentially of ferruginous silicate of alumina, and are remarkably free from substances which

ANALYSES OF ADOBE BY L. G. EAKINS.

Constituents.	No. 1. Santa Fé, N.M.	No. 2. Fort Wingate, N.M.	No. 3. Humboldt, Nev.	No. 4. Salt Lake City, Utah.
SiO_2	66·69	26·67	44·64	19·24
Al_2O_3	14·16	·91	13·19	3·26
Fe_2O_3	4·38	·64	5·12	1·09
MnO	·09	trace	·13	trace
CaO	2·49	36·40	13·91	38·94
MgO	1·28	·51	2·96	2·75
K_2O	1·21	trace	1·71	trace
Na_2O	·67	trace	·59	trace
CO_2	·77	25·84	8·55	29·57
P_2O_5	·29	·75	·94	·23
SO_3	·41	·82	·64	·53
Cl	·34	·07	·14	·11
H_2O	4·94	2·26	3·84	1·67
Organic matter	2·00	5·10	3·43	2·96
	99·72	99·97	99·84	100·35

are readily soluble in ordinary surface waters. Adobe, on the other hand, has a complex composition, and carries many substances which on exposure to percolating waters would be dissolved out. This difference is shown especially by the absence of calcium from residual clays and its abundance in adobe. Correlated with those differences in chemical composition are marked contrasts of colour. The prevailing and characteristic colour of residual clays is dark red; the adobe when not affected by organic matter is light yellow.

ANALYSES OF RESIDUAL CLAYS FROM THE SOUTHERN APPALACHIAN REGION.[1]

Constituents.	No. 1.	No. 2.	No. 3.
SiO_2	13·26	43·07	55·42
Al_2O_3	28·76	25·37	22·17
Fe_2O_3	16·80	15·16	8·30
FeO	—	—	trace
TiO_2	·64	—	—
P_2O_5	·10	—	—
Na_2O	—	1·20	·17
Ca_2O_3	trace	—	—
K_2O	—	2·50	2·32
MnO	trace	—	—
CaO	·37	·63	·15
MgO	·59	·03	1·45
H_2O (by ignition)	13·26	12·98	9·86
	100·07	100·64	99·84

No. 1, Residual clay resulting from the subaërial decay of trap rock from Wadesborough, N.C.

No. 2, Residual clay resulting from the subaërial decay of Trenton limestone, from Lexington, Va.

No. 3, Residual clay resulting from the subaërial decay of Knox Dolomite, from Morrisville, Ala.

[1] From U. S. Geol. Surv. Bulletins, No. 52.

(*To be concluded in our next Number.*)

II.—The Lias Marlstone of Tilton, Leicestershire.

By E. Wilson, F.G.S., and W. D. Crick,
With Palæontological Notes by E. Wilson, F.G.S.

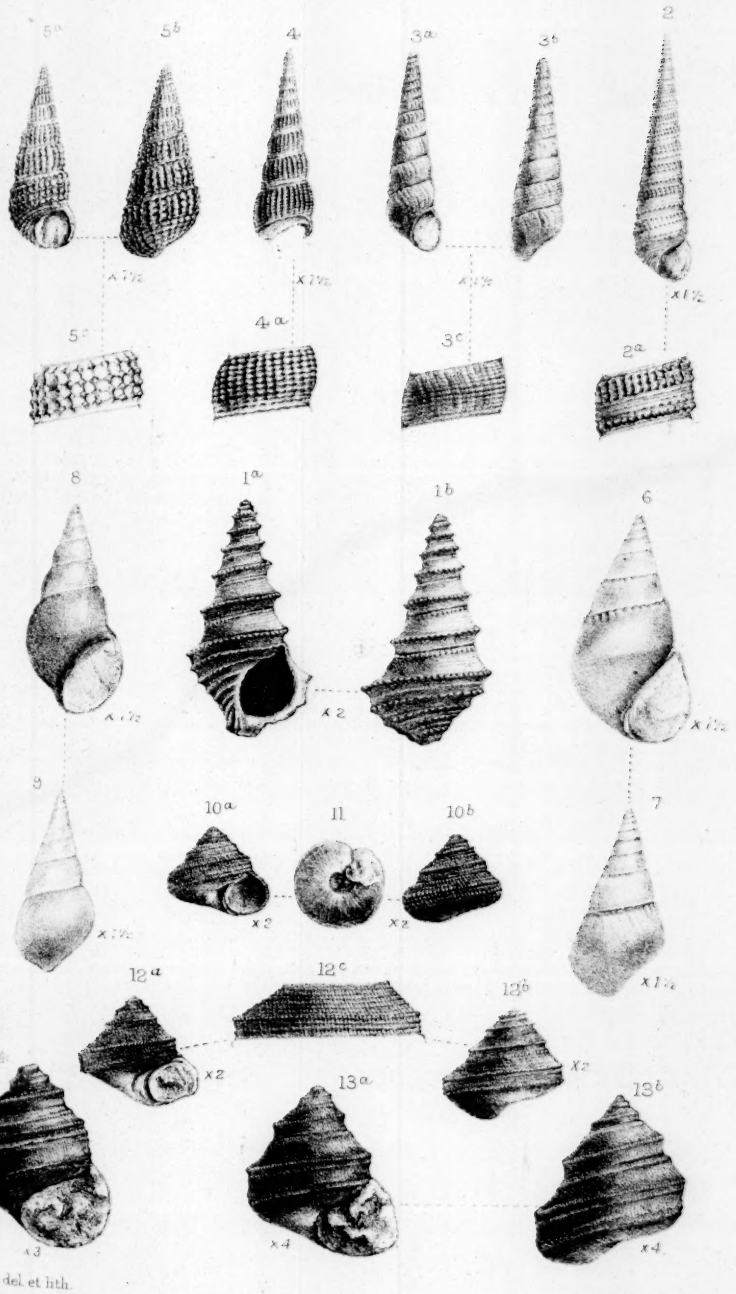
(PLATE IX.)

WHEN the new railway from Nottingham to Market Harborough was made, several instructive sections in the Upper and Middle Lias series were opened out between the latter place and Tilton. Most of these are now covered up and grass-grown, but one of the best is still partially laid bare in the deep cutting at Tilton Station. This Tilton section has become one of considerable interest to the geologists of the Midland district, from the complete and characteristic exposure which it gives of the Marlstone Rock of Leicestershire in its fully developed and unweathered form, and also on account of the rich fauna which that rock, and in particular its top or 'Transition Bed,' has here yielded.

The main purpose of this note is to present a list of these fossils with a detailed description of a few of them which are either new to the British Lias, or which have not hitherto received an adequate description. Before entering upon this part of our task, a very brief account of the stratigraphy of the district referred to will be desirable. A little to the south of Tilton Station the following section is exposed:—

	Ft.	in.
Upper Lias Shales: concealed in grass-grown slopes of the cutting, yielding a few fossils, e.g. *Harpoceras serpentinum, Stephanoceras crassum, Turbo Theodori, Trochus Northamptonensis, Leda ovum,* and *Belemnites* ... ... about	30	0
Middle Lias: *Marlstone Rock.* "Transition Bed" (Middle to Upper Lias); flaggy limestone, containing *Harpoceras acutum, Amaltheus spinatus, Stephanoceras commune, St. annulatum,* etc., *Nautilus truncatus, Belemnites elongatus, B. paxillosus,* etc., *Lima pectinoides, Pecten æquivalvis,* etc., many Gasteropods, *Pleurotomaria rustica, Cryptænia expansa, Trochus lineatus, Tr. ariel, Cerithium* (?) *confusum, C. ferreum,* etc. *Rhynchonella tetrahedra* var. *Northamptonensis, Terebratula punctata,* and fragments of fossil wood	0	9 to 0	6
Bluish-green ferruginous limestone, finely oolitic; *Harpoceras acutum, Stephanoceras commune, Pecten æquivalvis, P. lunularis, Terebratula punctata,* and *Belemnites,* in two blocks	4	3
Bluish-green finely oolitic ferruginous limestone with irregular seams of encrinital fragments; *Pecten æquivalvis, P. lunularis,* and *Belemnites,* in three blocks	4	2
Bluish-green rock, becoming locally a "jack";[1] *Pecten æquivalvis, Rh. tetrahedra, T. punctata* and *Belemnites*	1	6
Greenish arenaceous rock with a "jack" in upper portion and nodular below; *Rh. tetrahedra, T. punctata* and *Belemnites*	4	6
Greenish arenaceous rock with "jack" in upper half, and nodular below; *Amaltheus margaritatus, Gresslya lunulata, G. intermedia, Pleuromya* sp., *Rh. tetrahedra,* and *T. punctata*	3	6
	18	5
Middle Lias Shales with bands of sandstone and scattered limestone nodules, etc., *Am. margaritatus, Protocardium truncatum, Monotis cygnipes, Avicula inæquivalvis* and *Leda complanata,* etc. ... about 13 feet exposed, increasing, as the beds rise, to the north.	13	0

[1] "Jack," a quarryman's term for a bed of marlstone made up of an agglomeration of the shells of *Rhynchonella tetrahedra* and *Terebratula punctata.*



A. S. Foord del. et lith.

West, Newman imp.

Lias Marlstone Rock, Transition-Bed & Upper Lias Gasteropoda.

Tilton, Leicestershire

The Marlstone Rock in the Tilton railway-cutting, lying beneath a thick capping of Upper Lias Shales, is a hard massively-bedded grey ferruginous limestone, in appearance something like the Marlstone Ironstone of the Cleveland district of Yorkshire, but more finely-grained and duller looking, and containing also a much less percentage of iron. The rock is traversed by numerous joints, and along these and also along the bedding-planes to the depth of a few inches on either side the carbonate of iron has been changed, under the influence of percolating waters, into the hydrated ferric oxide. Coincidently with this chemical change the greenish-grey stone has assumed a rusty-brown colour, so that, when first opened out, the face of the rock presented a very prettily checked appearance. A few years' exposure to the atmosphere, however, has gone far towards toning down this variegation and covering the whole face of the Marlstone Rock with a uniform dull brown tint.

So far as the Leicestershire area is concerned, the "Transition Bed," at the top of the Marlstone Rock, appears to be confined to this single locality. This bed is remarkable for the numerous and varied organisms which it contains. Of these *Harpoceras acutum* is especially abundant, and characteristic of this horizon. Several Ammonites usually confined to the Upper Lias are here found associated with other forms characteristic of the Middle Lias, so that palæontologically the "Transition Bed" must be considered as really transitional between those two series, notwithstanding that it possesses the mineral characters of, and is welded to the Marlstone Rock. We have not therefore hesitated to apply to this bed the name given by Mr. E. A. Walford[1] and Mr. B. Thompson[2] to a similar bed which lies at the top of the Marlstone Rock in Oxford and Northamptonshire. It is mainly, if not solely, from this thin stratum that the Ammonites, as well as the Gasteropods, which are so numerous at Tilton, have been obtained. The "Transition Bed" may be examined *in situ* on a narrow ledge which projects a little from beneath the Upper Lias shales on the west side of the railway-cutting, and the best way to work it is to turn over and break up the slabs with a pick in wet weather, when the stone is softer and works much more readily. A small dip—about 1° S.E.—carries this bed and the Marlstone Rock beneath the line towards the south end of the cutting.

The material taken from the Tilton cutting has been used to construct the embankment at East Norton, about three miles to the south. Here blocks of the Tilton Marlstone lie about in great numbers. Under the action of the weather during the ten or twelve years which have elapsed since the line was made, the hard grey Marlstone Rock has been changed superficially into a comparatively soft brownish arenaceous ironstone, a change of the same kind, if not carried to the same degree, as that which, in the course of ages,

[1] "On some Middle and Upper Lias Beds in the Neighbourhood of Banbury," by Edwin A. Walford, F.G.S., Proc. Warwick Nat. and Arch. Field Club, 1878.

[2] "Notes on Local Geology," by B. Thompson, F.G.S., part x. "The Junction Beds of the Middle and Upper Lias," Journal Northants. Nat. Hist. Soc. vol. ii, p. 239, 1883.

has converted this dense grey ferruginous limestone into a porous and friable rusty brown ironstone over such large areas, where it forms the surface rock, in Leicestershire and Rutland.[1] This softening process has made it possible to extract a large number of fossils in a fairly complete state of preservation.

The list of Tilton fossils here given is in large measure founded upon specimens thus obtained. It is therefore in many cases impossible to say with absolute certainty from what part of the Tilton section these fossils came; but as we find that the chief repository for the cephalous mollusca, at any rate, at Tilton, is the top or "Transition Bed," we shall probably be pretty safe in assuming that most if not all of the similar organisms found in the Marlstone blocks of the East Norton embankment have been derived from that horizon.

Going south from Tilton, the Marlstone Rock rapidly dies away. In the railway-cutting near East Norton Station it can still be traced as a concretionary bed two or three feet in thickness, whilst between Keythorpe and Hallaton it is less than one foot thick; and nearing Market Harborough, it locally disappears altogether.

In the East Norton railway-cutting the grey clays of the "Communis zone" of the Upper Lias are exposed, and have yielded the following characteristic Upper Lias fossils:—

Stephanoceras commune, Sow.
,, *crassum*, Y. & B.
Harpoceras bifrons, Brug.
Belemnites subtenuis, Simpson.
Nortonia (*Purpurina*) *Patroclus*, d'Orb.
Inoceramus dubius, Sow.
Nucula Hammeri, Defrance.
,, *claviformis*, Sow.
Serpula tricristata, Goldfuss.

Palæontological Notes, by E. Wilson, F.G.S.

Although it has fallen to my lot to undertake the critical palæontology connected with the subject, I have to acknowledge very considerable assistance from my colleague in this department of our joint work. Mr. Crick has not only collected the great majority of the fossils mentioned in the Appendix, but he has also identified the whole of them, with the exception of the Gasteropoda and the species which I have described. The success attending Mr. Crick's researches in the neighbourhood of Tilton will be understood when I mention the fact that five years ago the total number of species which had been derived from the Marlstone Rock of the Leicestershire district, including Rutland and S.W. Leicestershire, did not exceed sixty, and that it is chiefly through his labours that this total has been increased to one hundred and ten.[2] Seeing that scarcely anything has been found in the Leicestershire district which has not also been found at Tilton, the Marlstone fauna of this single locality may be considered to fully represent that of the larger area referred to.

[1] As an illustration of the effect of atmospheric action in producing this change, it may be mentioned, that under the railway bridges where the Marlstone ballast has been protected from the rain, the rock remains in practically the same hard state as that in which it was first quarried.

[2] We are indebted to Mr. B. Thompson, F.G.S., of Northampton, for the privilege of inspecting his collection, and also for the loan of some of the most interesting of the fossils here described.

Without further preface I proceed to the consideration of certain of these fossils which are either new to science, or to the British Lias, or which call for more complete description or revised nomenclature. These fossils have all been derived from the Marlstone Rock of Tilton, Leicestershire, with the exception of the remarkable form first noticed, which is from the Upper Lias of East Norton, Rutland, and the peculiar interest of which must be my apology for noticing it in an essay not strictly dealing with Upper Lias palæontology.

NORTONIA (PURPURINA) PATROCLUS, D'Orbigny, 1847, Plate IX. Figs. 1*a*, 1*b*.

1847. *Turbo Patroclus*, d'Orbigny, Prodrome de Paléontologie, vol. i. p. 248.

Syn. 1850. *Purpurina Patroclus*, d'Orb., Pal. Franç. Terr. Jur. vol. ii. Gast. pl. 329, fs. 9–11.

? ,, *Purpurina Philiasus*, d'Orb., Pal. Franç. Terr. Jur. vol. ii. Gast. pl. 329, fs. 12–14, as *Turbo Philiasus* in the Prodrome, vol. i. p. 248.

1856. *Littorina Patroclus*, d'Orb. sp. Piette, Bull. Soc. Géol. France, 2nd ser. vol. xiii. p. 587.

1860. *Eucyclus Patroclus*, d'Orb. sp. Eudes Desl. Bull. Soc. Linn. Norm. vol. v. p. 138. Ibid. Eug. Desl. op. cit. p. 135.

non *Purpurina subangulata*, Mü. sp. Oppel, "Der Jura," p. 386.[1]

nec *Turbo subangulatus*, Münster, Goldfuss, Petref. Germ. vol. iii. p. 98, pl. 124, f. 5.

Description.—Shell thin, elongate, conical, apex acute; whorls 9, angular, screw-like, with a very prominent acute and crenulated keel, situated about two-fifths of the breadth of the whorl from the anterior suture; the whorls slightly concave and gently sloping from the keel to the posterior suture, more deeply excavated and steeply inclined inwards to the anterior suture; the sutures are bounded posteriorly by a raised simple spiral, anteriorly by a finely granulated one; the base is convex and fairly inflated, bearing five equidistant raised granulated spirals, between the middle three of which are two simple ones; the whole surface of the shell is covered with very fine spirals; the posterior border of the last whorl rises near its termination at the aperture, so as to slightly embrace the penultimate whorl: aperture ovate, a little oblique, the outer lip has its inner border considerably expanded, and its outer edge is thickened by a very narrow rim, and digitated by the keel and basal spirals; columellar border with a thin shelly deposit, columella outwardly twisted anteriorly; a narrow umbilical slit: anterior canal a broad shallow groove directed obliquely outwards, and effuse in front; posterior canal a narrow groove concealed beneath the overlapping portion of the last whorl. Length, 16 mm. Greatest diameter, 9 mm. Spiral angle, 37° Sutural angle, 125°. Proportion of last whorl to whole shell, 7 to 16.[2]

[1] Oppel was evidently mistaken in considering *Turbo Patroclus*, d'Orb., as the equivalent of *Turbo subangulatus*, Mü.

[2] Figs. 1*a*, 1*b*, accurately represent this form, except that in Fig. 1*a* the shelly callus on the inner lip should have been shown to continue as far as the end of the posterior canal.

Affinities.—D'Orbigny, in his Prodrome, gives a short diagnosis of a fossil, which appears to be rather widely distributed in the Upper Lias (étage Toarcien) of the centre and east of France, under the name *Turbo Patroclus*, and the same form appears in the "Paléontologie Française" as *Purpurina Patroclus*. Although no description is given in the latter work of this or indeed of any other *Purpurina*, it is obvious, from the illustrations in the atlas, that we have here our Rutland fossil. Yet the figure in the "Pal. Franç." is remarkable in this, that with the identical form and ornamentation of the English fossil, it presents apertural characters which are very different. Instead of the contracted aperture, thickened outer lip, and anterior and posterior canaliculation, possessed by our shell, we see depicted a large oval aperture with rounded margins and without the trace of a groove or canal. Evidently whilst the body of the shell of *Purpurina Patroclus*, D'Orb., is correctly delineated, the aperture is a beautiful but imaginary restoration; and the same observation will probably apply to *Purpurina Philiasus*, D'Orb., which is probably only a more highly ornate variety of *P. Patroclus*. It is true there are other Jurassic Gasteropods which have a spire and ornamentation extremely like *P. Patroclus*, and which nevertheless belong to different groups, *e.g. Alaria* and *Pseudalaria*; but the points of agreement between the fossil here figured and the illustration in the Pal. Franç. are, I hold, too precise to leave the above identification in doubt. It is to be noted also, that the name *Purpurina* given by D'Orbigny, implies that he considered these shells siphonostomatous, and this is expressed also in the original diagnosis of the genus, by that author in his "Cours élémentaire de paléontolgie,"—"Ouverture pourvue en avant d'un très étroit sillon qui remplace l'echancrure des Purpura." It will not be necessary to give, at this point, the history of *Purpurina*, the more so as this subject was not very long ago treated in some detail by my esteemed friend Mr. W. H. Hudleston, F.R.S., in the pages of the Geological Magazine,[1] and still more recently in the first part of his valuable Monograph on the Inferior Oolite Gasteropoda.[2] It is sufficient for my purpose to point out that, whilst Jurassic palæontologists have rightly followed Deslongchamps and Piette in restricting the genus *Purpurina* to forms possessing the general characters of *Purpurina bellona*, D'Orb., continental authors have been generally misled in their identification of *P. Patroclus*, D'Orb. as one of the Littorinidæ (an *Eucyclus*=*Amberleya*, or a *Littorina*), by the inaccurate figures in the Paléontologie Française. What then are the true affinities of the shell under consideration? In the aggregate of its characters—the rather elongate spire, the aperture with an expanded outer lip, slightly enveloping last whorl, outwardly twisted columella and clearly defined anterior and posterior canaliculation—this peculiar form seems to fall under the Cerithiidæ. It will scarcely, however, come within the genus *Cerithium* or any other established genus of that family. In certain details of form and

[1] Geol. Mag. Dec. II. Vol. IX. (1882), p. 11.
[2] Pal. Soc. British Jurass. Gast. pt. i. p. 8, and p. 83.

ornamentation *Purpurina Patroclus*, D'Orb., is remarkably like, and is probably related to, the type of Mr. Hudleston's new Jurassic genus *Pseudalaria* (*Alaria*) *Etheridgii*, Tawney, but the characters of the aperture are sufficiently different in these two shells to bring them under distinct generic groups. I believe it will be best to found a new genus for the reception of this remarkable Rutland fossil. I therefore, suggest for it the name *Nortonia*, in reference to the only British locality, East Norton, where it has at present been found. *Nortonia* might be briefly defined as a *Cerithium* with a very shallow anterior canal, and with eucycloid spire and ornamentation.[1] *Nortonia Patroclus* is perhaps one of those "common forms" which serve to link together several very diverse genera, such for example as *Cerithium* and *Pseudalaria* on the one hand, and *Amberleya* and *Purpurina* on the other.

I am indebted to Mr. Beeby Thompson, F.G.S., of Northampton, for the opportunity of examining this extremely interesting fossil.

Geological Horizon and Locality.—Upper Lias Shales, Railway-cutting, East Norton, Rutland.

CERITHIUM (CERITHINELLA ?) CONFUSUM, Tate, 1875. Plate IX. Figs. 2, 2*a*.

1875. *Cerithium confusum*, Tate, GEOL. MAG. Dec. II. Vol. II. p. 205.

I have several specimens of a highly elongate conical shell from East Norton, which answers to the description given by Tate of the above type. The state of preservation of these fossils is not sufficiently good to indicate with certainty their generic position. No figure accompanied the original description. I therefore give illustrations from our Leicestershire specimens.

Marlstone Rock, Tilton (East Norton embankment).

CERITHIUM FERREUM, Tate, 1875. Plate IX. Figs. 3*a*, 3*b*, 3*c*.

1875. *Cerithium ferreum*, Tate, GEOL. MAG. Dec. II. Vol. II. p. 205.

A number of shells have been obtained from the Marlstone Transition-bed of Tilton, and from the East Norton embankment, which correspond with Tate's type. No figures of this form having yet been published, I give illustrations from Tilton specimens to supplement the original description in the GEOLOGICAL MAGAZINE.

Marlstone Rock, Tilton (East Norton embankment and Tilton).

CERITHIUM COSTULATUM? Desl. 1842. Plate IX. Figs. 4, 4*a*.

1842. *Cerithium costulatum*, Desl. Mém. Soc. Linn. Norm. vol. vii. p. 199, pl. xi. figs. 12, 13.

There is a single imperfect specimen from East Norton, of an elongate conical shell, which appears to represent the above type of

[1] As a general principle, no doubt, it is not safe to found a genus or even a species on a single specimen, and this prevents my giving a more precise diagnosis of *Nortonia*. In justification of the above genus-making however, it may be said, that the characters of *N. Patroclus* are exceedingly well defined, that our solitary specimen is apparently an adult shell, and is exceptionally well preserved, and that there is evidence of its maintaining its characters constant over a wide geographical area.

Deslongchamps. The original illustrations are far from satisfactory: but the figured shell has a spire which is identical in its form and proportions, and apparently also in its ornamentation, with the above type, and I therefore make this identification with some confidence in its accuracy.

Marlstone Rock, Tilton (East Norton embankment).

CERITHIUM ILMINSTERENSIS, Moore, 1866. Plate IX. Figs. 5*a*, 5*b*, 5*c*.

1865–6. *C. Ilminsterensis*, Moore, Proc. Somerset Arch. and Nat. Hist. Soc. vol. xiii. p. 200, pl. iv. s. 12, 12*a*.

There are a number of specimens of a shell which agrees in its general characters with Moore's type. These shells are twice the length of the type, with the same number of whorls, and also differ from *C. Ilminsterensis*, Moore, agreeing with *C. Dayii*, Tate, in having four rows of subspinous encircling costulæ instead of three in each whorl. These small points of difference do not, however, seem to me to be characters of specific value.

Marlstone Rock, Tilton (East Norton embankment).

PSEUDOMELANIA (CHEMNITZIA) BRANNOVIENSIS, Dumortier, 1869. Plate IX. Figs. 6, 7.

1869. *Chemnitzia Brannoviensis*, Dumort. Etudes Pal. sur les Dépôts Jurass. du Bassin du Rhone, pt. iii. p. 218, pl. 27, f. 11.

The Marlstone blocks on the East Norton embankment have yielded us a number of shells which, although of much smaller dimensions, seem to agree with this type of Dumortier's. Seeing that this fossil has not hitherto been recorded from the British Lias, the following description and the illustrations here given may be of interest to the students of the English Jura. I adopt the generic designation of Pictet and Campiche as applicable to this form. *Description*:—"Shell conical, short, imperforate; spiral angle regular; whorls eight, flat or very slightly convex, covered with transverse lines of growth, forming thick irregular obscure plicæ, which give origin close to the suture posteriorly, to a series of nodules, slightly scalariform. Aperture high, oval, very oblique, without callosity over the columella. The last whorl occupies nearly half the total height. Length to width 32 : 17. Spiral angle 43°."

East Norton specimens give: Height 22 mm.; Diameter 11 mm.; Spiral angle 42°.

Marlstone Rock, Tilton (East Norton embankment).

PSEUDOMELANIA (PHASIANELLA) TURBINATA, Stoliczka, 1861. Plate IX. Figs. 8, 9.

1861. *Phasianella turbinata*, Stol., Gast. und Aceph. der Hierlatz-Schichten, Jahrbuch der k. k. Reichsanstalt (Wien), vol. xliii. p. 177, pl. iii. fs. 1. 2.

Like *Ps. Brannoviensis*, this is fairly common at Tilton. The genus *Pseudomelania* is suggested as a more fitting generic appellation for this form also.

Marlstone Rock, Tilton (East Norton embankment).

TURBO RUGIFERA, Moore, 1867. Plate IX. Figs. 10*a*, 10*b*, 11.

1867. *Turbo rugifera*, Moore, Middle and Upper Lias, Proc. Somerset Arch. and Nat. Hist. Soc. vol. xiii. p. 209, pl. vi. figs. 23, 24.
Syn. ,, *Turbo coronatus*, Moore, Ibid. p. 209, pl. vi. figs. 21, 22, 22*.
Syn. ,, *Pleurotomaria costulatum*, Moore, Ibid. p. 205, pl. v. figs. 12, 13.

Fresh description.—Shell turbinated, conical, umbilicated, apex acute; whorls 6-7, convex, narrow, with a broad flattened area bounding the sutures anteriorly, ornamented by sharply raised spiral lines, of which there are six or seven on the penultimate whorl, crossed by numerous fine, regular, close-set oblique radial lines, which raise the spirals into neat granulations at their decussations; base very slightly convex, umbilicus deep and generally large, with a squarely angulated and crenulated edge; aperture nearly round and nearly free from the last whorl; outer lip thin, inner lip with a lunate shelly expansion anteriorly. A few fine spirals may mark the circumference of the base, and very faint concentric striæ are sometimes discernible between these and the centre of the base, over which the fine radial lines are continued in flexuous curves. Height 9 mm.; Diameter 8 mm. to 9 mm.; Spiral angle 60° to 92°.

Note.—There is evidently considerable variation within the limits of this species, and different appearances are presented by different individuals according as the spire is more raised or depressed, and according as the varying relative strength of the spirals gives a rounded or an angulated appearance to the whorls. It is not therefore surprising that the late Charles Moore made three species out of the three variable specimens of *Turbo rugifera* which he obtained from the Middle Lias Marlstone of Ilminster. The specimens collected by Mr. Crick at East Norton serve to link these three forms together, and indicate that *Turbo rugifera* is the true type. Having carefully examined the type of *Pleurotomaria costulatum*, Moore, in Bath Museum, I see no reason for considering that shell a *Pleurotomaria*. It shows no trace of a sinus-band, and appears to be only a highly granular and somewhat squarely-keeled example of *Turbo rugifera*, Moore. *Turbo coronatus* also is only a more fully grown shell of the same type, with the difference that the greater prominence and coarseness of one of the spirals gives its whorls a coronated aspect.

Marlstone Rock, Tilton (East Norton embankment).

TROCHUS ROTULUS, Stoliczka, 1861. Plate IX. Figs. 12*a*, 12*b*, 12*c*.

1861. *Trochus rotulus*, Stol., Gast. und Aceph. der Hierlatz-Schichten, Jahrbuch. der k. k. Reichsanstalt (Wien), vol. xliii. p. 173, pl. ii. f. 7.

In the Journal of the Northampton Natural History Society for 1883[1] Mr. E. A. Walford, F.G.S., quotes this fossil from the Marlstone Transition-bed of Aston-le-Wall and Appletree, and gives an illustration (loc. cit. fig. 5), which can however hardly be considered a satisfactory representation of this very elegant little shell. I trust the figures here given may be more successful. *Trochus*

[1] Journ. Northants Nat. Hist. Soc. vol. ii. (1883) p. 296, pl. fig. 5.

rotulus, Stol., must not be confounded with *Trochus Pethertonensis*, Moore, from which it is quite distinct.

Marlstone Rock, Tilton (East Norton embankment).

PLEUROTOMARIA HELICINOIDES, Roemer, 1836. Plate IX. Figs. 13*a*, 13*b*.

1836. *Trochus helicinoides*, Roemer, Die Verstein. des Ool.-Gebirges, p. 150. pl. xi. f. 13.

Syn. 1867. *Trochus carinatus*, Moore, "Middle and Upper Lias of the South-West of England," Proc. Somerset Arch. and Nat. Hist. Soc. vol. xiii. p. 207, pl. 4, fs. 24, 25.

non *Turbo canalis*, Münster, nec *Pleurotomaria helicinoides*, Roemer, of Tate.

Whilst agreeing with Mr. Ralph Tate, F.G.S.,[1] that *Trochus carinatus*, Moore, is a *Pleurotomaria*, and (in all probability) identical with *Trochus* (not *Turbo*) *helicinoides*, Roemer, I cannot go so far as to admit that these are the same as *Turbo canalis*, Münster—a *Pleurotomaria* truly, but a different species I maintain, to the above. The figure entitled *Pleurotomaria helicinoides* in the Yorkshire Lias is, I consider, an illustration of '*Turbo*' *canalis*, Mü., and not of '*Trochus*' *helicinoides*, Roemer.

The following descriptions and the accompanying figures of Tilton specimens will indicate the chief points of difference between these two forms.

Pleurotomaria helicinoides, Roemer (assuming this to be the equivalent of *Trochus carinatus*, Moore), is a smooth and even polished shell, with very clean cut and angular sculpturing; the whorls have an acute keel anterior to the middle line; on this keel is placed the sinus-band, which is bounded by a single rather widely-spaced raised line on each side; from the sinus-band the whorl falls vertically in front to the anterior suture, and slopes gently back in a single concave sweep to a raised line or faint keel close to the posterior suture; the last whorl bears a third angulated keel anteriorly, bounding the broad vertical area below (*i.e.* anteriorly); the shell is covered with very fine curved lines of growth; the base is only slightly convex, smooth, but bearing a few very fine acute concentric lines either limited to the outer part or continuous to the centre; there is a very small umbilicus; the aperture is transversely ovate, with ill-defined columella. Height, 8 mm.; greatest diameter 7 mm.; Spiral angle convex, about 70°.

Marlstone Rock, Tilton (East Norton embankment).

PLEUROTOMARIA (TURBO) CANALIS, Münster, 1848. Plate IX. Fig. 14.

1848. *Turbo canalis*, Münster, Goldfuss, Petref. Germ. vol. iii. p. 95, pl. 193, figs. 12*a*, *b*.

Syn. 1878. *Pleurotomaria helicinoides*, Roem. sp. Tate, non Roemer, "The Yorkshire Lias," p. 338, pl. x. figs. 7*a*, 7*b*.

Whilst possessing the same general form of *Pl. helicinoides*, as above described, this shell presents rounded instead of angular contours, is far from smooth, and differs in its proportions as well as in its ornamentation. In *Pl. canalis* the keel bearing the sinus-band is situated posteriorly rather than anteriorly to the middle line,

[1] "The Yorkshire Lias," by Tate & Blake, p. 338, pl. x. fs. 7, 7*a*.

and is less angular, and the sinus-band is bounded by two much more closely set lines than in *Pl. helicinoides*. There is indeed a similar broad vertical and nearly smooth area below (anterior to) the sinus-band; but, excepting this, the whole shell from the apex of the spire to the centre of the base is covered with regular and prominent rounded spiral lines; two of these spirals situated in the middle of the sloping posterior portion of the whorls are more raised than the rest, and make the whorls appear more convex; the periphery of the last whorl also is rounded. Very slender curved radial lines may be discerned throughout the shell with the aid of a lens; but these are fainter than in *Pl. helicinoides*, and almost concealed by the spirals. The base is slightly convex; a very small, if any umbilicus; columella indistinct, and the aperture generally very like that of *Pl. helicinoides*. Height 8·5 mm.; width, 7 mm.; Spiral angle convex, about 75°.

Marlstone Rock, Tilton (East Norton embankment).

EXPLANATION OF PLATE IX.

Fig. 1. *Nortonia Patroclus*, d'Orb., Upper Lias, Railway cutting, East Norton, Rutland. *a*. Front view; *b*. back view. Enlarged twice.

,, 2. *Cerithium* (*Cerithinella* ?) *confusum*, Tate, Marlstone Rock, Tilton (East Norton Embankment). Enlarged one and a half times. *a*. Whorl further magnified.

,, 3. *Cerithium ferreum*, Tate, Marlstone Rock, Tilton. *a*. Front view; *b*. back view. Enlarged one and a half times. *c*. Whorl further magnified.

,, 4. *Cerithium costulatum* ? Desl., Marlstone Rock, Tilton (East Norton embankment). Enlarged one and a half times. *a*. Whorl further magnified.

,, 5. *Cerithium Ilminsterensis*, Moore, Marlstone Rock Tilton (East Norton Embankment). *a*. Front view; *b*. back view. Enlarged one a half times; *c*. Whorl further magnified.

,, 6. *Pseudomelania Brannoviensis*, Dumort., Marlstone Rock, Tilton (East Norton embankment). Front view. Enlarged one and a half times.

,, 7. *Ibid*. From another specimen. Back view, similarly enlarged.

,, 8. *Pseudomelania turbinata*, Stol., Marlstone Rock, Tilton (East Norton Embankment). Front view. Enlarged one and a half times.

,, 9. *Ibid*. From another specimen. Back view, similarly enlarged.

,, 10. *Turbo rugifera*, Moore, Marlstone Rock, Tilton (East Norton Embankment. *a*. Front view; *b*. back view. Enlarged twice.

,, 11. *Ibid*. Base, from another specimen, with an exceptionally large umbilicus. Similarly enlarged.

,, 12. *Trochus rotulus*, Stol., Marlstone Rock, Tilton (East Norton Embankment). *a*. Front view; *b*. back view. Enlarged twice. *c*. Whorl further enlarged.

,, 13. *Pleurotomaria helicinoides*, Roemer, Marlstone Rock, Tilton (East Norton Embankment). *a*. Front view; *b*. back view. Enlarged four times.

,, 14. *Pleurotomaria canalis*, Münster, Marlstone Rock, Tilton (East Norton Embankment). Enlarged three times.

(*To be continued.*)

III.—Was there an Arctic Ocean in the Mammoth Period?

By H. H. Howorth, Esq., M.P., etc., etc.

THE convergence of opinion is now so strong that the climate of Siberia in the Mammoth age was sufficiently temperate to enable trees to grow where only the bare tundra is at present found (if it does not necessitate our extending the forest zone at least as far north as the Liachof Islands), that it becomes at once interesting

and important to consider under what conditions such a result would be forthcoming.

The fauna of the polar lands is so uniform in all longitudes that they constitute one of the best-defined zoological provinces; a province to which the name Circumpolar or Panarctic has been given. So far as our evidence goes, the solidarity and identity of forms which now mark the circumpolar lands was shared in the Mammoth age by a considerable zone south of this area, a zone now constituting the greater part of the Palæarctic and Nearctic provinces of Mr. Sclater. If we are to judge by the remains which we can examine of the Mammoth and its contemporaries the Musk Sheep, the Bison, the Horse, the Elk, the Red Deer, the Reindeer, etc., etc., from the Old and the New World, there were not in the Mammoth age the distinctions which now mark off the mammals of North America from those of Northern Asia, and the panarctic and nearctic regions were then condensed into a fairly homogeneous zoological province.

This means of course that there must have existed in the Mammoth age a bridge over which the mammals at least could travel between the Old and the New World and *vice versâ*. Such a bridge would enable the animals to intermingle, and prevent isolation, which is the recognized *causa causans* of divergence of forms. If this be granted, and I cannot see how it can be contested, we have next to discover where this bridge was situated. In my work on the Mammoth I have followed in the footsteps of Mr. A. Murray, and enlarged his reasons for believing that it is quite impossible to suppose that this intermigration took place across *the ice* of Bering's Straits. In addition to the arguments there adduced, I would remark that if Bering's Straits were frozen over, it could only be under climatic conditions, when the Mammoth and its companions would find it impossible to exist on the land on either side of that water-way; and if we postulate (as the facts compel us to do) a comparatively mild winter climate in the Tchukchi peninsula and Alaska when the Mammoth lived, then we cannot also postulate that Bering's Straits were at the same time closed by thick ice such as would alone afford a highway for the animals to travel over. The notion that the intermigration took place over the ice of Bering's Straits is in fact an immature and very superficial one.

Putting aside a highway of ice across Bering's Straits, we are bound to postulate a land communication between Asia and America at this period, and the question is, where this bridge was planted.

It is quite clear that, wherever placed, it must have connected the Mammoth area on the one continent with the Mammoth area on the other, and since, the Mammoth, so far as we know, did not live in Japan, but was there replaced by another species of Elephant, this communication must have been north of Japan. Inasmuch as neither the Tichorhine Rhinoceros, nor the Hyæna, nor the Great Ox (*Bos primigenius*), whose remains are all found along the latitude of Central Siberia (the Rhinoceros occurring as far north as the river Wilui), have ever been found in America, and, so far as we know,

they never reached that continent, it is *prima facie* almost certain that the connection required must be found further north than these latitudes; and this is confirmed when we compare the living mammals and birds of Japan with those of America.

This makes it probable that the required bridge was in fact situated at a high latitude, where we must suppose that the conditions, although compatible with forest growth and consistent with the Mammoth, the Elk, the Red Deer, and other forest-frequenting animals finding food, etc., were too severe for the Rhinoceros, the Hyæna, and the Great Ox to find congenial quarters. That it was situated here is further proved by the very close resemblance, if not identity, of the living Rocky Mountain Sheep with that of Kamschatka.

Turning to another class of evidence. I have elsewhere adduced arguments to show that the mammal remains found in the New Siberian Islands and in the Bear Islands (the former 250 miles away from the Siberian mainland) are the remains of animals which actually lived where these remains occur. These islands and the opposite coast are at this moment rising from the sea, and laying bare new sand banks containing heaps of Mammoth and other bones, which are so fresh and sharp and unweathered, that it is clear they have been lying where the animals died. All this makes it exceedingly probable, if not certain, that when the Mammoth lived the Siberian Islands, the Bear Islands, and probably also the small islands discovered in the Jeannette Expedition, on which semi-fossil bones were found, formed part of the mainland, and that the more or less temperate conditions which I have postulated of Northern Siberia then extended at least as far as these islands.

This is very interesting, because, if we postulate so much, we have no difficulty in going further. The deepest soundings found by Nordenskiöld and other explorers between the Siberian Islands and the mainland are about 22 or 23 fathoms. This, again, is the greatest depth which has been sounded in the northern part of Bering's Straits between America and Asia; so that, if the movement of elevation which united the New Siberian Islands to the mainland was as general and widespread as the present elevatory movement in the Arctic regions is, then it follows that the uniting of the Siberian Islands with the mainland was accompanied by the bridging over of the space between North-Eastern Asia and Northern Alaska; thus forming an isthmus between the two continents. We may perhaps go even further, and say that, inasmuch as the present elevatory movement over the whole Arctic basin is general and widespread (as I ventured to show many years ago in a paper read before the Geographical Society, which was reprinted in the Arctic Manual), and inasmuch also as the general evidence goes to show that the portion of the Arctic basin east of Nova Zembla is shallow, it follows as very probable that a large portion of what is now occupied by that sea was in the Mammoth age dry land, and not only dry land, but land upon which trees would grow, and therefore within the climatic zone marked by forests.

This conclusion is largely supported by the fact that Maclure and other Arctic explorers actually found remains of some fossilized trees of species still living in North America in some of the islands of the Arctic Sea east of the River Mackenzie. These trees were rooted in the ground and *in sitû*, and grew therefore very far to the north of the present range of trees in the New World.

The reasoning I have ventured to adduce is based upon empirical evidence. If, as it seems to me, it is well founded, then it follows that the circulation of ocean currents in the Northern Hemisphere must have been entirely different from what it is now, since there was a barrier preventing the outgoing Arctic current from passing through Bering's Straits. Such a change must have materially altered the climate.

Secondly, the climate must have been very largely modified over the whole of Northern Asia in another and more direct way; for the north winds which are now so keen and killing, since they come straight from the great northern reservoir of ice which is never at a higher temperature than 32°, would then come from a land of grass and trees, and be correspondingly softened. This would have a very great effect upon the Siberian climate in the direction of making it consistent with the Mammoth, the Horse, and the Bison finding food and shelter in the area between Alaska and Northern Asia. *Pro tanto* this is a solution of the question of how to account for a mild climate in these high latitudes. It does not, however, exhaust the problem, and other causes remain, which perhaps you will let me discuss on another occasion.

IV.—On some Modes of Formation of Coal-Seams.

By J. G. Goodchild, F.G.S., H.M. Geol. Survey.

(Based upon a paper read before the Royal Physical Society, Edinburgh, on the 17th April, 1889.)

THE commonly-received theory that most coal-seams represent vegetable matter that has grown and has been entombed on the spot has never been received by all geologists with quite that measure of satisfaction that has been accorded to other theories of the same general nature. It has been felt again and again that the explanation referred to might be true enough for certain cases; but that in others it failed to account satisfactorily for all the phenomena. It involved too many complications—too nice an adjustment of the rate of growth of the vegetation to the rate of subsidence and of sedimentation—too much straining of the theory in question generally—to be accepted unhesitatingly by those accustomed to judge of such facts for themselves. That certain beds of coal have been formed by the growth of vegetation on the spot no reasonable person can doubt: the only question is whether that is true of every coal-seam. Many competent observers have thought it is not; and the number of those who are dissatisfied with the view set forth in most text-books is certainly on the increase. Mr. W. S. Gresley, and several other geologists, have lately advanced good arguments in favour of other views, which many are disposed to accept as correct.

Perhaps the truth in this case, as in many others, may be that similar results have been attained in a variety of ways, and that, instead of there having been but one mode of formation of coal-seams, there have probably been many.

We might briefly consider some of these at this point. The formation of coal simply requires that a certain quantity of pure vegetable matter should be left at any given spot under conditions that insure its conversion before its chief constituents shall have passed into the inorganic condition. These results may be brought about in a variety of ways. Inland, for example, coal or its representative, lignite, may be formed through the burial of peat beneath the alluvium of lakes or of rivers. In marine areas it may arise through the sedimentation of inland peat whose constituents have been re-sorted and drifted out to sea. The submergence and subsequent burial of maritime beds of peat *in situ* may, under suitable conditions, give rise in another way to beds of coal. The entombment of masses of drift-timber that have floated seawards must, again, largely contribute to the same result. Marine vegetation must occasionally play an important part in the formation of deposits of carbonaceous matter on the sea-bottom.[1] Then there is the important factor of the growth, decay, and entombment on the spot, of lagoon vegetation, originating in an area where deltas are subsiding intermittently, and with minor oscillations of level. Lastly, coal may be formed, as an ordinary sedimentary deposit, by the slow accumulation, in quiet water, of deciduous, or other, vegetable matter, floated seawards from riparian forests. Each of these modes of formation of coal must have played important parts in the formation of coal-seams, at every period of the earth's history, from the dawn of vegetation down to the present day. The *exclusive* advocacy of any one mode is therefore as illogical as it is unnecessary. It seems to me that the last mode referred to has not received quite as much consideration as its importance deserves, and I propose therefore, while attaching equal importance to the other modes, which are already well understood, to consider this particular one in some little detail. Before proceeding to do so it may be as well to review some of the facts connected with the mode of occurrence of coal-seams in general, with a view of arriving at a clearer idea of their various histories.

It is now admitted on all hands that the principal constituents of nearly every coal-seam represent so much carbon that has at one time existed in the form of carbonic acid in the atmosphere, whence it has been extracted by the vital forces of growing vegetation. Subsequent pressure accompanied by certain chemical changes, well understood, have converted this fixed carbon into coal. The precise nature of the vegetable matter forming the coal varies within wide limits, not only on account of the varied ages, or the geographical position, of the seams themselves; but even within the coal-seams belonging to any one geological period and situated at the same part of the earth's surface. There is, further, much diversity in the

[1] I know of no evidence that *marine* vegetation (i.e. *Algæ*) is capable of conversion into coal.—Edit. G.M.

proportion that the different parts of the plants bear to each other in different seams. As a rule, tree trunks form but a small part of any coal-seam; and in the rare cases where they do so occur, they are not found in the position of growth, or extending upwards through the seam, but are prostrate, and lie parallel to the bounding surface of the coal. The coarser portions of the organic constituents of coals present a mixture, in variable proportions, of the more solid parts of the vegetation in a fragmentary state, together with portions of the cellular and the vascular tissues of the plants. Even such constituents as these are commonly in the minority. Fronds, leaves, and small stems occur rather more plentifully. But the greater part of the recognizable organic constituents of most coal-seams consist of a varied assortment of finely-divided vegetable tissue, together with spores, spore-cases, and bodies of that general nature. Some parts of nearly every coal-seam commonly fail to show any definite structure at all. The relative proportions of these varied constituents differ considerably in different coals; but the peculiar constitution of each coal-seam as a whole remains tolerably uniform over large areas. Not only do the constituents of each coal-seam as a whole differ from those of the seams associated with it, but the component layers of each seam differ amongst themselves. Every coal-seam is seen, on a very cursory examination, to be simply an aggregate of carbonaceous laminæ, which are ordinarily thin, and are occasionally of almost microscopic proportions. A close examination of these laminæ shows that they differ each from the other to a much greater extent than a cursory examination would lead one to suppose. More than that. The structural characters of each of the lamina, whatever its thickness, remain constant to such an extent as to enable one to identify that particular lamina over a large area. Practical coal-miners are well aware of this fact, although they may not always be able to point to the precise nature of the distinction in each case. One lamina may contain nothing but spores and spore-cases; a second next it, above or below, may consist of leafy matter alone; a third may be characterized by the constant presence of mineral charcoal, representing the vascular tissues of the old vegetation; a fourth may be devoid of any evident traces of organic structure; or another lamina of the same coal-seam may contain, along with its organic constituents, a variable amount of impurities of organic origin. And yet, however, the several laminæ may differ among themselves, they are found to retain their own special characteristics throughout the whole of a large coal-field. Even where the coal happens to be changeable, as it often is near old irregularities of the floor upon which it lies, the rate of change is far from being rapid, except, of course, where the coal is splitting up through interlaminations or partings of inorganic matter.

Some coal-seams pass into shales, by a progressive increase in argillaceous impurities; but they rarely, perhaps almost never, graduate into sandstones; although some irregular and lenticular deposits, which clearly represent drifted vegetation, may often do so. Coal not uncommonly graduates into carbonaceous clay ironstone.

In rarer cases still the change can be traced through this last into impure limestone. Of this more presently.

Sedimentary formations of nearly every geological period contain coal-seams in one part of the earth's surface or another; and under every variety of geological or of geographical circumstances they present much the same features; and—allowance being made for the changes the containing rock may have undergone—their composition also is in nearly all cases practically constant. It would seem, therefore, that the formation of coal does not require any very exceptional conditions, such as an excess of carbonic acid in the atmosphere, or other abnormalities.

There is often a curious (and significant) relation between the nature of the rocks associated with coal and that of the vegetable matter entombed therein. In the Carboniferous series proper the sedimentary strata associated with the coals are usually shales; fireclays, and beds of sandstone of various degrees of coarseness also occur. In certain areas limestones and calcareo-siliceous beds ("cherts") are also found. Vegetable remains commonly occur dispersed throughout all of these, though the proportion varies much with the nature of the rock. It is in the coarse, drifted, material forming the sandstones, that tree trunks, if they occur at all, are most commonly found. And it is here that they are so often found embedded stem upward and root downward, reminding one so forcibly of the "snags" that are common in the sandy deposits of tropical rivers. (It should be noted, in passing, that the centre of gravity of most of the trees of the Carboniferous period must have lain close above the roots; so that in floating, they must have travelled root downwards, and as the decay of the soft interior proceeded, they must have tended invariably to sink to the bottom in nearly the position of growth.) The shales associated with coals rarely contain trees (I have not come across any proof that they ever do so); but fronds and leaves occur in plenty, and, more rarely, stems and small boughs may occur as well. The fireclays (which are commonly regarded as old soils that have been exhausted of their alkalies and iron by the growth thereon of vegetation) often, but by no means invariably, contain roots—the well-known *Stigmaria*—in addition to the vegetable constituents found in the shales. Some sandstones show these *Stigmaria* roots as well, whether the rock is directly associated with coal or not. If limestones occur with the coals, these rarely contain traces of coal, except as lenticular masses, which are clearly due to the entombment of vegetable matter that has been drifted. A fine and well-known example of this kind is seen in the Mountain Limestone of Ingleton in North Yorkshire.

A careful consideration of these facts relating to coal will make it clear that, whatever be its precise mode of origin in any given case, coal presents all the characters of a stratified deposit. It resembles most closely, in many of its characters, those strata that have slowly and quietly accumulated in nearly-still water. The resemblance to a stratified deposit is certainly not delusive and to be attributed to the effect of subsequent compression, because, as we have seen, the

component laminæ have each structural characters of their own, marking them off from those above and below, and remaining constant over wide areas.

Much stress has been laid upon the intimate association that is said to exist between seams of coal and beds of fireclay. But every practical mining engineer must be well aware of the fact that the two kinds of rock are by no means universally associated. Thick beds of fireclay occur in the Argill Coal-field near Kirkby Stephen, Westmorland,[1] without a trace of coal near. One such bed is thirty feet in thickness. On the other hand, in certain rich coal-fields such a rock as fireclay (or as gannister) is conspicuous by its absence.

Having glanced at an outline of the facts, we may pass on to consider one of the various modes of formation of coal—the others referred to are so obvious that no one can well have any doubt as to their validity in the present connection. As an illustration of what takes place, we may consider the sequence of events that must obtain in the case of any large river that is carrying seawards the spoils of a riparian forest region. Such a river transports vast quantities of inorganic materials; as well as more or less floating animal matter, which is partly terrestrial, partly fluviatile, partly estuarine; there is, in addition, variable quantities of vegetable matter of all kinds—big tree trunks, boughs, stems, leaves, fronds, spores and spore-cases, and all the miscellaneous deciduous vegetable matter that may be derived from every part of the forest region above. The river does not transport its heterogeneous burden at a uniform rate of motion, nor does it drop it all at the same place. Far from that. The coarser mineral sediment drifts seawards along the bottom for a time, but finally comes to rest at no great distance from the land. Some of the tree trunks that have travelled so far as to become water-logged at this point sink here; and, obeying the laws of gravity, they sink with their heavier ends downward and are eventually buried root downward in the coarse sediment. Most of the animal matter, which decomposes quickly, also sinks near, and may be buried along with the trees. The finer inorganic matter drifts in suspension farther out to sea, where it subsides in crescentic zones on the seaward side of the coarser material, and entombs such of the vegetable matter as may have become water-logged at that part. Farther out to sea, or where the submarine currents have lost most of their transporting power, the finest sediment, after rolling about in clouds for a time, gradually subsides to the bottom, and there entombs also such of the vegetable matter whose constitution has enabled it to travel so far. Seaward of the zone where this happens quiet and still water prevails on the sea-bed. Here the littoral forms of marine life do not commonly reach; and here also, it is commonly assumed that little or no organic matter transported from the land ever reaches. Most of the animal remains that may have floated down the river have probably all sunk, and been

[1] "On the Former Extension of Coal Measures over Edenside," Trans. Cumb. and Westmd. Assoc. No. vii. p. 163.

entombed in the zones nearer the land; but with vegetable matter the case is different. Vegetable matter has a low specific gravity, and its ordinary tendency is to float. It is only under certain conditions, and after long maceration, that it sinks at all; and even in that case such of it as is in a fine state of division is especially long in reaching the sea-bed, even where the bottom is quiet and comparatively shallow. In the case we are supposed to be reviewing some of the vegetable matter that enters the river near its source becomes so far water-logged by the time the estuary is reached as to subside to the bottom just outside the zone where the sea-bottom is affected by the stronger submarine currents. Much more of the vegetable matter remains suspended long enough to be transported to a zone on the seaward side of the last referred to. But most of what has been here referred to as the deciduous parts of the vegetation, the leaves, fronds, the resinous spores and the spore-cases, together with the half-decayed parts of the cellular and vascular tissues of the plants themselves, remain in suspension so long, and subside to the bottom so gradually, that by the time they have finally settled, the submarine currents have transported them seawards to a zone well outside that attained by any but the very finest sediment.

There must, therefore, be a constant sorting out of the varied material brought down by the river, and it must be that which remains longest in suspension that is transported farthest from the land. In this way accumulations of vegetable matter, pure, and unmixed with mineral sediment, must be slowly and quietly gathering off the mouths of most of the rivers that traverse regions abounding in vegetation.

It is important to remember that all the while the physical conditions of land and sea remained unchanged, the deeper water deposits, at all events, would continue to be laid down uniformly; so that, if no disturbance of the relative levels of land and sea occurred, there would practically be no limit to the quantity of vegetable matter that might thus accumulate in the course of time.

There is another point to be noticed in more detail. The rate at which any given vegetable organism will sink depends upon several conditions. Its specific gravity is one of the most important; then follows the time it has been exposed to maceration; the velocity of the currents affecting it must affect the results materially; and even the form of the vegetable body itself must be taken into account as a factor. But the most important factor of all is the power of resistance the body presents to the forces that are tending to reduce it to the inorganic condition. If it rots quickly when exposed to maceration, it will become water-logged after only a short journey, and may reach the bottom within the zone of deposition of even the coarser sediment. But if it be of a nature to resist the effects of maceration for long periods (as the resinous spores, etc., most certainly are), then it will be longer in becoming fully saturated with water, and may drift in suspension many miles to the seaward of the point where its original fellow-travellers came to the ground.

One can readily imagine to what different distances the leaf of an oak and one of some tender annual would travel if they started together in the same current. And the difference thus exemplified was probably often as marked in the case of the vegetation forming coal.

In consequence of this relative power of resistance to maceration, a further sorting out of the different vegetable bodies from each other must be in progress. Leaves of one kind subside within one zone, those of another kind within a second; spores, being resinous, must resist maceration longer, and therefore reach the sea-bottom at a zone more distant still; and so on, each kind tending to be sorted out into zones by themselves.

With any disturbance of level the absolute position of any one of these zones must change; but their relative order must, if other conditions remain constant, be the same as before. With a slight upward movement, or with a shallowing of the water of the estuary, due to the seaward advance of banks of sediment, shore conditions advance seaward, and clay, or even coarser material, may be spread over the zone where under former conditions only vegetable matter was left. Such a process might continue until the whole of the depth between the sea-level and that of the old submarine peat had been silted up and converted into dry land. Soils might thus be formed, and lagoon vegetation start into existence, not far above the old submarine deposits of carbonaceous matter. With a slight depression thalassic conditions advance towards the former coast-line, and limestone might be built up where just before coal had been formed. In this case it is important to remember that the formation of the coal would still go on, only that the outer zone where this happens would be situated on the landward side of the limestone zone. The two, however (the coal and the limestone), must be contemporaneous, even though they are not deposited in exactly the same area.

The amorphous parts of coal, and, indeed, much of its present character, owe their peculiarities to the fact that there is a constant reaction going on in sea-water between the sulphate of lime in solution and the bituminous matter carried down in suspension. The bituminous matter is acted upon by the sulphate of lime, and is thereby partly dissolved, and under particular conditions returns to the solid form; while the decomposing vegetable matter, in its turn, reacts upon the sulphate of lime, giving rise eventually to a precipitate of lime in the form of carbonate. Where the proportion of vegetable matter is in excess, beds of impure limestone result; but where, as in the case of inland lakes, an unusually large percentage of sulphate of lime is present, geological facts warrant us in concluding that the whole of the vegetable matter is dissolved. Hence the marked (and otherwise puzzling) absence of vegetable remains in Red Rocks of all kinds. Hence, also, the presence of bitumen in connection with saline lakes. I am inclined to believe that the conversion of vegetable matter into coal is partly affected by the action of the sulphate of lime in sea-water. Where this sub-

stance is only present in small quantities, as in fresh-water lakes, the vegetable matter is left simply as lignite.

If we study the details recorded from borings in the deposits forming any great delta, we cannot fail to be struck with the correspondence between these details and those of the case we have been considering. The beds of "peat" so commonly met with generally represent, I consider, the deeper-water accumulation of vegetable matter I have so often referred to. Some, of course, may be true soils; but the majority are far more likely to be due to the causes above noticed. If this view be accepted as true in the main, then it is obvious that we must cease to regard these beds of "peat" as evidence of the former presence of dry land at a platform that owes its present position to submergence at a later date. They should be regarded as simply an integral part of the normal sedimentary deposits that had been formed there; the peat representing, not shallow water nor subaërial conditions, but simply deposits that had been laid down in the ordinary course in water that was comparatively deep.

We have but to imagine such beds of the submarine "peat" exposed to the necessary conditions of pressure and chemical change, and beds of coal would be formed identical in nearly all respects with such as had grown, had died, and had been entombed on the spot.

V.—Note on some Pebbles in the Basal Conglomerate of the Cambrian at St. Davids.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

MORE than one kind of rock, as we learn from Dr. H. Hicks and other writers,[1] occurs in the conglomerate which forms a well-marked base to the Cambrian system at St. Davids. Sometimes the pebbles are mainly vein quartz, sometimes felstone predominates, but occasionally, as in the neighbourhood of Nun's Chapel Bay, quartzites (using the term rather generally) are not uncommon. At one place, not far from a quartz-felsite dyke, these are rather large, occasionally about a foot in diameter. From this locality, while spending a few days at St. Davids in 1882, I brought away specimens of three of the most marked varieties of quartzite, of which I had slices prepared, thinking that as examples of rocks which were probably far from modern at the beginning of the Cambrian age, their structures might be instructive. In this I was not disappointed, and now that I have had many opportunities of comparing them with various quartzose rocks, both Palæozoic and Archæan, I think a brief description may have some general interest.

The first, and least remarkable, was broken from a rather angular block about a foot in its longest diameter. The rock is a quartzite, rather compact or even vitreous in aspect, nearly white, or of a very pale pinkish-grey colour. Microscopic examination shows it to be composed almost entirely of quartz. This occurs in grains, from

[1] Q.J.G.S. vol. xl. p. 567, *id.* (Blake) p. 294.

subangular to rather rounded in form, which are often about ·015″ to ·02″ in diameter. It is difficult to be quite certain of the boundaries of the original fragments, but secondary quartz more or less in optical continuity with the original grain has undoubtedly been deposited to some extent. Here and there a tiny flake of light-coloured mica, or a little opacite or ferrite, may be seen, indicating no doubt the residue of the dusty material once present in the original sandstone. One or two of the fragments exhibit a compound structure. Very minute fluid cavities with bubbles are rather numerous in the quartz grains; but on these, and a few tiny accidental microliths, it seems needless to dwell.

The next specimen comes from a block of nearly the same size. It is a fine-grained quartzite, slightly rougher in texture and fracture than the last, and of a purple-grey colour. Examination with a lens shows that, though composed mainly of quartz, a good many tiny flakes of silvery mica are present. Microscopic examination shows that the quartz grains, though rather smaller in size, are very commonly about ·012″ diameter, and somewhat rounded or bluntly polygonal, but slightly wavy in outline. Occasionally they are separated by a flake of mica: more often a few specks of opacite or ferrite indicate the position of the original contact surface. Doubtless the original grains have been augmented by deposit of secondary quartz; but, even more than in the former case, it is difficult to fix the position of the old surface. Still I should infer that the grains had once been fairly regular in outline. Fluid cavities appear to be less numerous than in the former case. The mica is white or a very pale greenish tint; it occurs sometimes in isolated flakes, but is frequently associated and occasionally almost forms "nests," when it is usually mixed up, more or less, with dark granules, which are probably, in part at least, hematite and magnetite. The larger flakes are about ·01″ in length, but the majority are smaller. The sections are fairly rectilinear in outline: the shorter ends not appearing either ragged or "nipped." Even if originally fragmental, these flakes must have been subsequently enlarged, and I suspect that they have been to a great extent, if not wholly, developed *in situ*. Possibly some tiny crystals of zircon and rutile are present, with perhaps a grain of epidote; but these accessories are so unimportant, that I have not cared to waste time in attempting to determine them with precision.

The next fragment is from a fairly rounded stone about four inches long. This quartzite is whitish in colour, and in structure is fine-grained and rather schistose. Microscopic examination shows that quartz is the principal mineral. The grains commonly present 'ragged' outlines, and are unequal in dimensions, tending to lie with their longer axes parallel. When viewed with crossing Nicols each grain exhibits a border tinted rather differently from the inner parts. This might be produced by the overlapping of the irregular edges of two contiguous grains; but as the tint in some cases continues practically uniform all round the grains, it must result either from a fairly regular thinning of the latter, or

from a deposit of secondary quartz which is not in optical continuity with that of the original grain. The mica flakes, practically colourless, vary in length up to about ·006″, and often lie between this and ·004″, they tend to lie parallel one to another, and exhibit bright tints with crossed Nicols. The slide contains two or three grains of brown tourmaline, some microlites of zircon and rutile (probably), some tiny flakes of iron-glance, and some opacite or ferrite.

It seems reasonable to suppose that all these rocks were originally clastic, consisting of moderately worn fragments of quartz, which must have been derived from some more ancient and probably granitoid rock, with a variable amount (in one case extremely little) of mud, which has subsequently been converted into white mica and secondary quartz.

My collection contains a fair number of slides representing quartzites of Palæozoic or presumably Palæozoic age, from various localities in Britain[1] and from a few other quarters. These, however, differ slightly from the first-named specimen, and considerably from the others: the alteration of the constituents, especially in regard to the more earthy, being less complete. But the second specimen bears in some respects a close resemblance to certain quartzites which I obtained from the Huronian Series near Sudbury in Canada.[2] In these we find mica flakes, if not developed, at any rate completed *in sitû*. True, in most of these specimens the mica is brown, but white mica may also be found, especially in one whitish quartzite which much resembles this rock from St. Davids. Again, the third fragment from that locality is different from any specimen of Palæozoic quartzite which I have ever examined, and closely resembles the schistose quartzites or quartz-schists which I have found associated with the more fine-grained mica-schists and chlorite-schists in the Alps and elsewhere. It almost exactly resembles one described by me[3] from above Windisch-Matrei (Tyrol), except that the last-named is slightly coarser in texture and a little more definitely foliated. Both the second and third specimens from St. Davids present some resemblance to a quartzite[4] which, at Pen-y-Parc, near Beaumaris (Anglesey) occurs in association with one of the greenish-grey micaceous schists, which are so abundant in that island.

The quartz grains in the more highly-altered quartzose rocks of clastic origin exhibit under the microscope (as no doubt has often been remarked) a fairly distinct peculiarity of aspect. The edges of the individual grains appear, as it were, fused together. The line of junction is often slightly wavy, irregular, almost inter-

[1] *e.g.* N.W. Scotland, Hartshill, Lickey, Wrekin, Stiper Stones, N. Wales, Cherbourg, the Ardennes, pebbles from Carboniferous and Triassic rocks, etc.

[2] Described in Q.J.G.S. vol. xliv. p. 32.

[3] Q.J.G.S. vol. xlv. pp. 87–105.

[4] See Q.J.G.S. vol. xxxix. p. 47 (note). Prof. Blake (*id.* vol. xliv. 475, 508) calls this a quartz knob, and seeks to show that it has more resemblance to a vein product than to a rock of clastic origin. I cannot, of course, answer for the specimen which he examined, but can only say that if my slide does not represent a quartzite, I have never seen one.

locking, as if the mass had been reduced to a plastic condition and then slightly but rather uniformly compressed in all three dimensions of space, or as if the grains had been growing gradually outwards at the expense of a semi-fluid magma which had filled up all the interstices. A rather similar aspect is presented by quartz grains, which have formed (often mainly by segregation—though no doubt frequently around a clastic nucleus) in a 'silty' rock which has been much affected by 'contact metamorphism.'[1] A similar aspect is presented by the quartzes in certain quartzose schists, which are presumably metamorphosed sediments, and which do not appear to have been subsequently very distinctly modified by pressure. This peculiarity—though distinct to an accustomed eye—is not very easy to describe in words or even to represent diagrammatically; but an idea of it may be obtained by comparing the lower half of figure 3 (omitting some of the small interstitial granules) with figs. 1 and 2 and the upper halves of 3 and 4 of plate xxxi. in the late Prof. R. D. Irving's excellent paper on the Archæan Formation of the North-Western States.[2] A hard and fast line, as indeed these figures show, cannot be drawn between this structure and that of an ordinary quartzite—still, I believe, a very large number of specimens can be classed under one or the other type; and I am quite certain that if these three specimens from St. Davids had been sent to me (as specimens often are sent) without any clue as to their geological horizon, I should have returned them with the remark that they had the appearance of being very ancient rocks.

Here, then, at the base of the British Cambrians, we find, in three specimens selected as fair samples of the materials of a conglomerate, structures, of which one indicates that the rock is not likely to be anything but ancient; the second is more like the structure of the Huronian quartzites than of any indubitable Palæozoic quartzite which I have examined; and the third resembles that of quartz-schists, which are almost certainly Archæan, though they probably do not belong to the oldest part of that series. The structures also of these two are not such as are suggestive of pressure metamorphism, but of slow molecular change, under constraint indeed, in the presence of water, and at a fairly high temperature. Thus the evidence of these pebbles, so far as it goes, is favourable to the opinion that, as a general rule,[3] rocks of Archæan age may be identified by their structures, and that the conditions under which they consolidated have recurred, if at all, only rarely and locally.

[1] See, for instance, Q.J.G.S. vol. xliv. p. 16.

[2] United States Geological Survey, Fifth Annual Report, 1883–4.

[3] I must not be supposed to assert that a hard, fast, and universal line can be drawn between Archæan and Palæozoic (or Cambrian and Pre-Cambrian) any more than between Palæozoic and Mesozoic or between any other geological groups, systems, or classificatory divisions.

VI.—The Present State of the Archæan Controversy in Britain.

By Charles Callaway, D.Sc., F.G.S.

THE Archæan question in this country may be said to be about twelve years old. Rocks older than the Cambrian had indeed been recognized by Murchison and Sedgwick, and brief notices of Pre-Cambrian masses at St. Davids had been published by Salter, Harkness, and Hicks; but the Archæan campaign was formally opened by Dr. Hicks in a paper read before the Geological Society in November, 1876. The attack upon the old views was followed up by Prof. Bonney, the Rev. Edwin Hill, Prof. Hughes, and myself, and, more recently, by Prof. Lapworth and Prof. Blake. The defence has been conducted by Dr. A. Geikie. The controversy has been animated, and not without sensational incidents. Great diversity of opinion has existed even amongst the assailants, and many important divisions of the inquiry must be still regarded as unsettled. The most noteworthy difficulty which has arisen in the progress of our work is the dynamic theory of metamorphism. My chief purpose in writing this paper is to show how far this theory affects our old conclusions; but I shall incorporate any facts necessary to give a true outline of the present state of opinion on the Archæan rocks. I use the word "Archæan" as strictly equivalent to "Pre-Cambrian."

St. Davids.—Dr. Hicks originally described[1] two groups, the Dimetian and the Pebidian. He subsequently[2] introduced an intermediate formation, the Arvonian. According to Dr. A. Geikie,[3] the Pebidian is merely the base of the Cambrian, while the Dimetian and Arvonian are granites and porphyries intrusive in the bedded rocks. Prof. Blake[4] regards all Hicks's groups as Archæan, but he would convert them into one continuous series. I cannot speak from adequate personal examination of the ground; but analogy with other districts would rather suggest to me that the granite and porphyry (the Dimetian and Arvonian) form a group distinct from and older than the Pebidian, and that the Pebidian also is Pre-cambrian.

Shropshire.—Out of the "intrusive greenstones" of Murchison and the Survey, it has been found possible to construct two well-marked Archæan groups.[5] The older of these, consisting of granite and gneissic rocks, I have called Malvernian, from their probable equivalence to rocks of the same character at Malvern. But the new views of metamorphism deprive the term "equivalence" of its ancient meaning. The rocks in question are granites and diorites, which under the influence of earth-pressures have here and there acquired a gneissic structure. These igneous rocks are alike in the two localities, the results of the metamorphism are similar, and there is in both cases a marked unconformity to the Cambrian. We,

[1] Quart. Journ. Geol. Soc. 1877, p. 229.
[2] *Ibid*, 1879, p. 285.
[3] *Ibid*, 1883, p. 261.
[4] Quart. Journ. Geol. Soc. 1884, p. 294.
[5] *Ibid*, 1879, p. 643.

therefore, may infer a general equivalence; but it cannot be proved that the process of schist-making was strictly contemporaneous in the two districts. It may however be safely asserted that the Malvernian rocks are Older Archæan; for the principal types, granites and modified diorites, occur as derived fragments in the conglomerates of the Newer Archæan of Shropshire.

The Newer Archæan, the Uriconian, is a volcanic group resembling the Pebidian of St. Davids, of which it is the probable equivalent. But recent discovery suggests that this well-known formation may have to be thrown back to a period more remote from the Cambrian than has commonly been supposed.

The slates, grits, and conglomerates of the Longmynd have been usually regarded as the stratigraphical equivalent of the Llanberis and Harlech groups. For some years, I have doubted the accuracy of this determination. In 1878,[1] in announcing the discovery of Cambrian rocks at Caer Caradoc, I described a thin band of limestone in the Hollybush Sandstone at the north-eastern extremity of the ridge. This limestone was fossiliferous, yielding, besides *Kutorgina cingulata* and *Serpulites fistula*, several species of indeterminable Brachiopoda and obscure fragments of a trilobitic nature. Subsequent visits brought to light better specimens, which convinced me that the fauna was of a very ancient facies; and I have been in the habit of provisionally referring it to the Menevian epoch. As there appeared to be a considerable break between the Hollybush Sandstone and the Longmynd series, it seemed hardly possible to retain the latter in the Cambrian. In this unsettled state of the question, I proposed[2] in 1887 to call this great group of rocks by the name of "Longmyndian." This term has been adopted[3] by Prof. Lapworth, and he has obtained most important evidence in favour of the Archæan age of the strata. Mr. H. Keeping, of Cambridge, working under his direction, has collected from the limestone at Caer Caradoc material which enables Prof. Lapworth to "recognize a large and well-marked species of *Olenellus*," as well as to make out the generic characters of more of the Brachiopoda, and he concludes that the Pre-Cambrian age of the Longmyndian is "a matter of fair probability." Prof. Blake goes further, and correlates[4] the Longmyndian with his "Upper Monian" of Bray Head. To sum up, we find that the most recent discovery, so far from invalidating my conclusions with reference to the occurrence of Archæan rocks in Shropshire, renders it possible that a third system will be added to the list. We should thus be able to record the existence in the West Midland area of three magnificent rock-systems of Archæan age, viz. 1. *Malvernian* (igneous and igneo-metamorphic), 2. *Uriconian* (volcanic and sedimentary), 3. *Longmyndian* (sedimentary). I have not here discussed the Rushton Schists,[5] because their position is uncertain; but I have little doubt that they are Pre-

[1] Quart. Journ. Geol. Soc. 1878, p. 758.
[2] Trans. Shrop. Arch. Soc. 1887.
[3] Geol. Mag. Nov. 1888, p. 484.
[4] Quart. Journ. Geol. Soc. 1888, p. 543.
[5] Described in this Magazine, Aug. 1884, p. 362.

Uriconian, and would therefore have to be thrown in with the Malvernian. They have the appearance of schists which have been derived from igneous rocks by shearing, and the strike (north-westerly) is the same as that of the Malvernian.

The Midlands.—The volcanic rocks of Charnwood, described[1] by the Rev. E. Hill and Prof. Bonney, are now generally regarded as Pebidian. Slight exposures of old masses underlying the Cambrian have been recognized at the Lickey and near Nuneaton by Prof. Lapworth, Mr. W. J. Harrison, and others.

Malvern.—By almost universal[2] consent the crystalline rocks which form the nucleus of the Malvern range have been referred to Archæan times. In 1880[3] I separated the masses forming the eastern spurs of the Herefordshire Beacon from the rest of the crystallines, and placed them in the Uriconian. The older rocks (Malvernian) were regarded by Phillips and Murchison as metamorphosed sediments with extensive intrusions of syenite and granite. Dr. Holl went further than these authors, and contended that many of the massive rocks also were of sedimentary origin. None of these writers attempted to construct a sequence out of the Malvernian. At one time, I cherished the hope that this might be done; and, in 1887, Mr. Rutley[4] submitted to the Geological Society the details of a time-succession which he considered he had established. This scheme assumed that the foliation of the gneisses and schists coincided with an original sedimentation. My own work at Malvern had been leading me to a very different conclusion, and, when Mr. Rutley's paper was read, I gave some of my results,[5] my main contention being that many of the foliated rocks were igneous masses which had acquired a parallel structure under pressure. I have since, in papers to the British Association,[6] and the Geological Society,[7] unreservedly extended this theory to all the schistose rocks of Malvern. If I am right, it is obvious that the order in which the foliated bands occur cannot indicate a time-sequence. The new views on metamorphism, therefore, destroy the hope of constructing a succession amongst the Malvernian rocks; but they do not affect the evidence as to the age of the respective Archæan systems represented in the Malvern Hills.

Caernarvonshire.—Papers on this area have of late years been published by Prof. Hughes, Prof. Bonney, Dr. Hicks, Mr. F. T. S. Houghton, the late Mr. E. B. Tawney, Mr. A. Harker, Prof. A. H. Green, and Prof. J. F. Blake. Dr. Hicks identifies his three rock-groups in the area between Caernarvon and Bangor. Prof. Bonney admits the Archæan age of these granitoid and rhyolitic masses; but would assign them to two periods only. Prof. Hughes is in agreement with these observers on the main question; but he places some of the detrital Archæan of Prof. Bonney in the Cambrian.

[1] Quart. Journ. Geol. Soc. 1877, p. 754; 1878, p. 199; 1880, p. 337.

[2] Murchison's opinion that these rocks are metamorphosed Cambrian has probably no living advocate.

[3] Quart. Journ. Geol. Soc. Nov. 1880, p. 536.

[4] *Ibid.* 1887, p. 481. [5] Quart. Journ. Geol. Soc. 1887, p. 525.

[6] Reports, 1887, p. 706; and 1888, p. 653. [7] Read April 17, 1889.

The rhyolites near Llyn Padarn and the felsitic and schistose masses of Lleyn district are also claimed as Archæan by Dr. Hicks, and Prof. Bonney admits the claim so far as Llyn Padarn is concerned. Mr. Tawney and Mr. Harker have, however, maintained that some of the igneous masses in the Lleyn area are intrusive in the Ordovician strata This may well be the case; but I am convinced that the quartz-felsites south of Bangor and on Llyn Padarn are truly Archæan. The massive conglomerate running from Llyn Padarn to the south-west along the crests of Moel Tryfaen and Mynydd y Cilgwym is packed with rounded fragments of the subjacent felsite, while the Cambrian grits further west are largely composed of similar material, which also occurs in smaller proportion in the Cambrians near Harlech.

Anglesey.—Prof. Sedgwick was amongst the first to express the opinion that this island contained rocks older than the Cambrian. In our own times, Dr. Hicks, fresh from his discoveries in South Wales, visited the area, and rapidly concluded that his three systems were represented respectively by the granite (Dimetian), the halle-flinta (Arvonian), and the schists (Pebidian). Prof. Bonney and Prof. Hughes, approaching the study of the rocks from different sides, agreed that the island contained extensive tracts of Archæan rock; but they did not venture upon detailed conclusions. My own work in Anglesey extended over several years, and led me to believe that the crystalline and hypo-crystalline rocks were mainly Archæan, but that they could not be grouped into more than two distinct systems, Older Archæan (gneissic) and Newer Archæan (slaty). The latter I did not attempt to subdivide into a definite succession. The former appeared to display a sequence of the following groups, taking them in ascending order:—(1) Halleflinta, (2) Quartz-schist, (3) Limestone, (4) Grey gneiss, (5) Dark schist, (6) Granitoidite. Thus the case stood as the result of work upon the old lines.

My enquiries in Ireland and at Malvern led me in the direction of dynamic metamorphism, and, in the light of the new ideas, I re-examined the most important of my Anglesey sections. I found that some of the green schists were modified diorites, that the grey gneiss and associated schists were modified felsite, and that the limestones of the Older Archæans were probably endogenous segregations. These results I communicated to the British Association[1] in 1887. On the same occasion, Prof. J. F. Blake[2] reported that some of the igneous rocks of the island "put on a foliated character in places." I followed up my clues in the following year, and obtained confirmatory evidence of my previous conclusions. I also ascertained that the halleflinta of Llanfaelog was transitional between felsite and gneiss, and that the granite was a truly igneous and intrusive rock, associated with and apparently passing into quartz-felsites which were quite distinct from the above-named felsite. My original reading of the Newer Archæans did not require modification. They were sedimentaries which had been more or less metamorphosed. These results were made known[3] to the British Association in 1888.

[1] Report, p. 760. [2] *Ibid*, p. 231. [3] Report, p. 654.

It was obvious from these discoveries that the sequence in the Older Archæans would have to be differently interpreted. It ceased to be a succession in time, and was useful merely as a description of the distribution of the respective rock-types. But what we lost in one direction we gained in another and more important one. An empirical sequence was replaced by a revelation of true causation. Thus, the halleflinta, quartz-schist, and grey gneiss are produced from felsite by pressure, the limestone is formed from the same rock by segregation, the dark gneiss is modified diorite, and the granitoidite is a true granite intrusive in the felsite, the diorite, and their modifications.

Prof. Blake in his paper[1] in the Journal of the Geological Society, and in his Report[2] to the British Association in 1888, agrees that the rocks in question are Archæan, that the Newer Archæans are largely sedimentary, that the granitoidite is a true granite, and that the diorite has sometimes been modified into schist; but he does not admit that the grey gneiss and associated schists are of igneous origin, and he contends that the Lower and Upper Archæans form a continuous series.

The Highlands of Scotland.—The history of recent discovery in this remarkable region has been so well told by Prof. Bonney,[3] Prof. Lapworth,[4] and the officers of the Geological Survey,[5] that repetition is unnecessary. It is agreed on all hands that the Hebridean gneiss is Archæan; but there is not the same consensus of opinion as to the age and origin of the Eastern gneiss. In my chief paper[6] on the Highlands, I showed that, by enormous thrusts from the east, the Hebridean had been forced over the Ordovician (or Cambrian) rocks for great horizontal distances, and that the Eastern gneiss overlay the Ordovician in a similar manner. As the younger gneiss was a truly metamorphic rock, quite unlike any of the Ordovicians, I inferred its Archæan age, and called it "Caledonian." In the debate on my paper, Prof. Lapworth, who had visited the Erribol district, said that the sections he had seen there seemed to support my view. Indeed, in the state of our knowledge at that time, no other inference appeared to be possible. However, Prof. Lapworth soon after revisited his old ground, and in 1884 we were startled by the extraordinary theory that the Eastern gneiss was a melange of Hebridean, Ordovician, and igneous, rocks, which, under the influence of the great thrust, had been sheared out and in part recrystallized. In the following year, the Survey admitted the new conclusions, even to the length of adopting Prof. Lapworth's view of the origin of the Eastern gneiss. I have not been to the Highlands since 1882; but, considering the nature of the evidence adduced, and the competence of the witnesses, as well as the confirmatory proofs I have collected in Ireland and at Malvern, I am disposed to concede to the new theory a high degree of probability.

[1] 1888, p. 463. [2] p. 367.
[3] Presidential Address, Quart. Journ. Geol. Soc. May, 1885.
[4] Geol. Mag. 1885, p. 97.
[5] Quart. Journ. Geol. Soc. Aug. 1888, p. 378.
[6] Quart. Journ. Geol. Soc. Aug. 1883, p. 356.

Ireland.—Not much has yet been done amongst the Archæans of Ireland. Leinster has been slightly studied by Prof. Sollas and Prof. Blake, as well as by myself. I have held that there is reasonable evidence of two formations, corresponding to the Gneissic and Slaty groups of Anglesey. Prof. Sollas[1] appears disposed to agree with me in reference to the Gneissic series; but the newer group at Howth and near Wexford he would associate with the Bray Head rocks. Prof. Blake,[2] however, who has given considerable attention to Anglesey, regards the Howth group as the equivalent of his "South Stack series," and therefore as Archæan. Prof. Blake separates—I think rightly—the Howth series from the rocks of Bray Head, and he places the latter in a newer group, very high up in the Archæan.

The metamorphic rocks of Galway and Connemara are probably Archæan. No theory of metamorphism can affect the question of their age. The solution of some difficult problems will probably be found in this remarkable area.

There are indications of the existence of Archæan rocks in Donegal, but the region will require much hard work. The granitoid masses supposed by some to be "Laurentian" prove to be intrusive granites locally modified by pressure into a gneiss.

The Lizard and South Devon.—The banded gneisses and other schists of the Lizard have been studied by Mr. J. H. Collins, Prof. Bonney, and Mr. Teall. By Prof. Bonney,[3] the parallel structure was regarded in 1883 as evidence of an original sedimentation; but Mr. Teall[4] in 1887 contended that the banded gneisses were igneous complexes which had undergone deformation under earth-pressures. Prof. Bonney refers the Lizard schists to the Archæan period, a view which may not be materially affected by theories of origin. The same author describes[5] the micaceous and chloritic schists of the South Devon coast, and considers them a prolongation of the Lizard rocks. Miss C. A. Raisin[6] adds further descriptions of the Devon district.

The Channel Islands.—The Rev. E. Hill has given considerable attention to the crystalline rocks of this group of islands. He describes,[7] *inter alia*, hornblendic schists and felspathic gneisses, and assigns them to the Archæan, contending that their great dissimilarity from the Cambrian and later strata of the adjacent parts of Brittany renders their Palæozoic age highly improbable. This evidence is not likely to be affected by questions of origin.

The length of this bare sketch, in which only the principal contributions are mentioned, will give some idea of the activity of the workers in the Archæan field. Errors have no doubt been made; but, having regard to the extreme obscurity of some of the evidence

[1] Brit. Assoc. Report, 1887, p. 708.
[2] Quart. Journ. Geol. Soc. 1888, p. 542.
[3] Quart. Journ. Geol. Soc. Feb. 1883, p. 1.
[4] Brit. Assoc. Report, p. 707; and Geol. Mag. Nov. p. 484.
[5] Quart. Journ. Geol. Soc. Feb. 1884, p. 1.
[6] *Ibid.* Nov. 1887, p. 715.
[7] *Ibid.* Aug. 1887, p. 322.

and to the misleading influence of old theories of metamorphism, very substantial results have been gained. I believe I am correct in saying that all who have studied the question with any degree of thoroughness, that is to say, in more than one or two localities, have come to substantially the same conclusion. Whether there are one, two, or three Archæan systems—whether, if there are more than one, they are separated by broad or narrow gaps—are questions on which unanimity is not yet attained; but there is little difference of opinion as to the existence and distribution of the Archæan masses as a whole. The dynamic theory of metamorphism affects certain details of the Older Archæans, it renders correlation amongst igneo-metamorphic masses somewhat less precise, and it materially alters all the old views on the Eastern gneiss of Sutherland. On the other hand, it opens up questions of the greatest interest, and renders comparatively intelligible some of the earliest chapters in the earth's history.

VII.—Note on some Points in the Nomenclature of Fossil Reptiles and Amphibians, with Preliminary Notices of Two New Species.

By R. Lydekker, B.A., F.G.S., F.Z.S.

HAVING occasion in a work now in the press to refer to certain fossil Reptiles and Amphibians of which the commonly accepted nomenclature requires revision, I think it advisable to make the necessary amendments in a Journal specially devoted to Geology and Palæontology. I also take the opportunity of giving two new scientific names to Reptiles from the Wealden.

The name *Diplovertebron*, Fritsch, as being a hybrid word, may be amended to *Diplospondylus*. *Notochelys*, Owen, being preoccupied by Gray, may be changed to *Notochelone*.

Since there is every probability that *Ornithopsis Hulkei*, Seeley, is identical with *Hoplosaurus armatus*, Gervais, while the latter is probably not generically separable from the earlier *Pelorosaurus*, I propose to adopt the name *Pelorosaurus armatus* for the Isle of Wight species, on the assumption that it is distinct from *P. Conybeari* of Sussex. The Kimeridgian and Oxfordian species described as *Ornithopsis* may likewise be referred to *Pelorosaurus*.

The teeth from the Wealden provisionally referred by Mantell and Owen to *Hylæosaurus* are now known to be Sauropodous, and since they appear to be too small to belong to any of the described Wealden forms of that group, I propose to refer them provisionally, on account of their small size, to the genus *Pleurocœlus*, Marsh, with the name *P. valdensis*. I am confirmed in this reference by a small dorsal vertebra in the British Museum (No. R. 1626), from the same deposit, which closely resembles that of the typical American species, and probably belongs to the same form as the teeth.

Finally, I propose the name *Megalosaurus Oweni* for the metatarsus from the Wealden figured by Owen in his 'Wealden and Purbeck Reptilia,' pt. iv. pl. xi. as *Hylæosaurus*, and referred by

myself to *Megalosaurus* in the 'Cat. Foss. Rept. Brit. Mus.' p. 167, under the name of *M. Dunkeri*. I am induced to make this new species because metatarsals obtained by Mr. C. Dawson from the Wadhurst Clay of Hastings are clearly specifically distinct from the above-mentioned specimen, and I provisionally refer them, on account of their larger size, to *M. Dunkeri*. The type of *M. Oweni* appears to belong to the right side, instead of to the left, as stated by its describer.

NOTICES OF MEMOIRS.

I.—On a possible Geological Origin of Terrestrial Magnetism.[1] By Professor Edward Hull, M.A., LL.D., F.R.S., Director of the Geological Survey of Ireland.

THE author commenced by pointing out that the origin and cause of terrestrial magnetism were still subjects of controversy amongst physicists, and this paper was intended to show that there is cause for believing the earth itself contains within its crust a source to which magnetic phenomena may be traced, as hinted at by Gilbert, Biot, and others; though, owing to the want of evidence regarding the physical structure of our globe in the time of these observers, they were unable to identify the supposed earth's internal magnet.

The author observed that in the opinion of many geologists there exists beneath the crust an outer and inner envelope or "magma" the former less dense and highly silicated, the latter basic and rich in magnetic iron-ore. This view was in accordance with the views of Durocher, Prestwich, Fisher, and many others. The composition of this inner magma, and the condition in which the magnetic iron-ore exists, were then discussed, and it was shown that it probably occurs under the form of numerous small crystals, with a polar arrangement; each little crystal being itself a magnet, and having crystallized out from the magma while this latter was in a viscous condition, the crystalline grains would necessarily assume a polar arrangement which would be one of equilibrium. Basalt might be taken as the typical rock of this magma.

The thickness and depth of the magnetic magma beneath the surface of the globe were then discussed; and while admitting that it was impossible to come to any close determination on these points owing to our ignorance of the relative effects of increasing temperature and pressure, it was assumed tentatively that the outer surface of the effective magnetic magma might be at an average depth of about 100 miles, and the thickness about 25 or 30 miles. The proportion of magnetic iron-ore in basaltic rocks was then considered, and it was shown that an average of 10 to 15 per cent. would express these proportions; and assuming similar proportions to exist in the earth's magnetic magma, we should then have an effective terrestrial magnet of from $2\frac{1}{2}$ to 3 miles in thickness. The thickness, however, might be very much greater than here suggested.

[1] Read at the Royal Society, May 16, 1889.

Instances of polarity in basaltic masses at various localities were adduced in order to illustrate the possibility of polarity in the internal mass. Magnetic polarity had been found by the author to exist in segments of basaltic columns.

The subject of the polarity of the globe was then discussed, and it was pointed out how the position of the "magnetic poles" leads to the inference that they are in some way dependent upon the position of the terrestrial poles.

The author regarded the so-called "double poles" as merely *foci* of attraction due to protuberances of the magnetic magma into the exterior non-magnetic magma, and maintained that there was really only a single magnetic pole in each hemisphere, embracing the whole region round the terrestrial pole and the *stronger and weaker magnetic foci*, and roughly included within the latitude of 70° within the northern hemisphere.

It was pointed out that the poles of a bar-magnet embrace a comparatively large area of its surface, and hence a natural terrestrial magnet of the size here hypothecated may be inferred to embrace a proportionably large tract for its poles.

In reference to the question why the magnetic poles are situated near those of the earth itself, this phenomenon seemed to be connected with the original consolidation of the crust of the globe, and the formation of its internal magmas.

It was suggested that, owing to the differences of temperature which must have existed in the polar regions, as compared with those of the equatorial, the process of solidification may have been more rapid in the polar regions than elsewhere, and it was inferred that in the case of the magnetic magma the process of crystallization and the polar arrangement of the particles of magnetic iron-ore might have proceeded from the poles towards the equator in radial directions. The manner in which the phenomena of magnetic intensity, and of the dip of the needle at different latitudes, could be explained on the hypothesis of an earth's internal magnet, such as is here described, was then pointed out; and the analogy of such a magnet with a magnetic bar passing through the centre of the earth was illustrated. On the other hand it was conceivable that the process of solidification might have commenced at the Equator—extending towards the poles, and thus the polar arrangement would naturally arise.

The author then proceeded to account on geo-dynamical principles for the secular variation of the magnetic needle, and also endeavoured to show how the objections that might be raised to the views here advanced, on the grounds of the high temperature which must be assumed to exist at the depth beneath the surface of the magnetic magma, could be met by considerations of pressure; and on this subject read a letter which he had received from Sir William Thomson, F.R.S.

II.—Beitrag zur Kenntniss der Mikrofauna aus den oberjurassischen Feuersteinknollen der Umgegend von Krakau. Von Thaddäus Wisniowski. Jahrb. der k. k. geol. Reichsanstalt, 1888, Bd. xxxiv. pp. 657–702, taf. xii. xiii.

Notes on the Microscopic Fauna from the Upper Jurassic Flint-nodules in the Neighbourhood of Cracow. By Thaddeus Wisniowski.

IN the limestone strata of the White or Upper Jura formation near Cracow there are layers of flint nodules similar to those in the Upper Chalk of this country. The flints vary from dark to grey in tint, in the latter a great variety of microscopic organisms can be distinguished. These principally consist of detached sponge-spicules, some of which are very perfectly preserved, whilst others have been dissolved and only the infilled casts of their canals remain. The spicules evidently belong to a variety of siliceous sponges, the monactinellid and tetractinellid forms predominating. There are also some minute forms resembling the flesh-spicules of existing hexactinellids. In the flints from one particular locality radiolarians appear instead of sponge-spicules; of these 19 different species have been recognized by the author, and ten are new. Foraminifera are also fairly abundant in the flints mingled with the siliceous organisms; but as only their infilled casts have been preserved, it has not been practicable to distinguish more than 10 species. In contrast to the abundant remains in the grey nodules, there are very few to be found in those of a dark tint; but as there are numerous gradations between these two varieties, it is reasonable to conclude that the silica in both has been derived from the same organisms, and that these have been completely dissolved in the dark nodules. Figures of the different forms are given in the accompanying plates. G. J. H.

III.—Ueber das Devon in Devonshire und im Boulonnais. Von E. Kayser in Marburg. Neues Jahrbuch für Mineralogie, etc. 1889, Bd. I. pp. 179–191.

PROF. KAYSER (in company with Prof. Gosselet, of Lille, and some other geologists) visited the classical region of North and South Devon last autumn under the guidance of Mr. W. A. E. Ussher, and in this paper he gives some details of considerable interest regarding the geological structure and fossils of these areas as compared with the corresponding strata in Germany. Prof. Kayser concludes that in South Devon there is the closest resemblance, alike in the Upper, Middle, and Lower divisions, to the Devonian succession in West Germany, and this is further shown by the occurrence of similar eruptive greenstones in both countries. On the other hand, considerable differences are shown in the North Devon Series. There are here no representatives in the Upper Division either of the *Clymenia* Limestone, or of the Adorf *Goniatite*, or the Iberg Coral-limestone; in the Middle Division the *Stringocephalus* and *Calceola*-limestones are wanting, and there is no near resemblance either in

the Rhenish or in the Belgian-French Devonian of the prevailing hard quartzitic sandstones and grauwackes of the Lower Division in North Devon. The Pilton beds and the Cucullæa zone or Baggy beds correspond rather to the Belgian than to the Rhenish Upper Devonian, and there is nothing analogous, either in the Rhine district, Belgium, or Northern France, to the Pickwell sandstones and the slates of Morte and Ilfracombe. Not only are the limestones of the South Devon Series almost entirely replaced by the slates and sandstones of the North, but there is further in this area a complete absence of the greenstone and schalstein.

IV.—On the Spinose Rhynchonellæ (Genus *Acanthothyris*, D'Orbigny) found in England. By S. S. Buckman, F.G.S., and John Francis Walker, M.A., F.G.S.—On *Terebratula bisinuata*, Lam., from the London Clay of Hampshire. By J. F. Walker, F.G.S.—On Oolitic Brachiopoda new to Yorkshire. By J. F. Walker, F.G.S. (From the Yorkshire Philosophical Society's Report, 1888, York, 1889.)

THE first of these papers gives a history and bibliography of the genus *Acanthothyris* as distinguished from *Rhynchonella*, and describes the species and varieties (ten in number) occurring in England, with their geological and geographical distribution.

In the second paper Mr. Walker records the occurrence of numbers of the hitherto rare *Terebratula bisinuata*, in beds, apparently of Bracklesham age, near Fareham, in Hampshire. The last paper contains a list and descriptions of sixteen new species and varieties of Brachiopods, some of them new forms, discovered in the Oolitic strata of Yorkshire since 1876.

REVIEWS.

I.—Bulletins of the Geological Society of France.

THE last number of the Bulletin of this Society (ser. 3, vol. xvi. No. 8, 1888) contains several papers of considerable interest.

We have the concluding portion of a paper by M. Œhlert on some Devonian Pelecypoda, and this is illustrated by phototypes of the author's drawings. Species of *Avicula*, *Pterinea*, *Cypricardinia*, *Sanguinolites*, *Goniophora*, *Pteronites*, *Modiomorpha*, *Ctenodonta*, *Palæoneilo*, and *Guerangeria* are described.

M. W. Kilian gives an account of a number of Cephalopoda and one Brachiopod, from the Lower Cretaceous strata of Provence. These include Ammonites, which are noted under the perplexing names of *Lytoceras*, *Silesites*, *Holcodiscus*, *Pulchellia*, and *Hoplites*; also species of *Heteroceras*, and a *Rhynchonella*.

M. R. Zeiller notes the presence in the *Grès bigarré* of the Vosges, of the fern *Acrostichites rhombifolius*.

M. H. Douvillé contributes some studies on *Caprina*, *Caprinula*, and *Plagioptychus*.

M. Hébert gives the second part of his paper on the Cretaceous formation of the Pyrenees, dealing with the Senonian stage.

Of more general interest, perhaps, are the new studies on the chain of St. Beaume, in Provence, by M. Marcel Bertrand.

In a previous communication the author showed that the strata in Provence had been subject to great mechanical disturbance, for remnants of Triassic and Jurassic strata were found reposing on Upper Cretaceous rocks. He now gives additional examples of these "*phénomènes de recouvrement*," and draws attention to evidences of remarkable twisting in the overfolded strata and to sinuosities that were subsequently produced.

Taking a section across the region from St. Zacharie to St. Beaume, he illustrates how the Jurassic, the Neocomian and Cretaceous strata are inverted on the north, being bent over in that area towards the south; while further south the strata are plicated and faulted in places, but the faults are represented as dying out deep down in the folds to whose influence they are due. In the troughs of the synclinals are preserved remnants of Jurassic strata which rest on Upper Cretaceous beds.

The explanation of these structures is given in an accompanying diagram. The Jurassic, Neocomian and Cretaceous strata that were laid down in sequence (interrupted by the local overlap of Neocomian by newer strata) were considerably denuded; great lateral compression followed, and this was attended by the remarkable overfolding of the strata in both the northern and southern portions of the region. The beds were sharply bent over and pushed forward, so that the uppermost strata in the overfolds were disrupted, and the overfolds became over-thrusts or thrust-planes—the disturbance in the north being the more pronounced. Further compression led to undulations in the mass of the strata, so that the comparatively undisturbed beds beneath and the superincumbent overthrust beds were together plicated. Subsequent denudation has left as it were only outlying patches of the older overthrust rocks, and these are portions that occupied the synclinal folds, having by reason of their structure withstood the agents of denudation. Thus the mechanical agents have left their imprint for the most part in relief, and the confused character of the topography finds an explanation. These great earth-movements, it should be added, took place before the Tertiary strata were deposited.

The chief interest in this district is in the evidence afforded of the double folding, and in the overfolds on the north and on the south being inclined the one towards the other. Such a structure reminds the author of the celebrated section in the *Alpes de Glaris* by M. Heim. H. B. W.

II.—The Geological Survey of Bavaria.

Geognostische Jahreshefte. Erster Jahrgung 1888. Herausgegeben von der geognostischen Abtheilung des K. Bayer. Oberbergamtes in München. (Cassel, Fischer.)

IN this, the first year-book brought out by the Geological Survey of Bavaria, there are some important papers on the geology of that country. Amongst others, Dr. von Ammon gives a description

of the fauna in the brackish Tertiary strata of Lower Bavaria, illustrated by a plate; Dr. Leppla writes on the Bunter Sandstone in the Haardtgebirge, and also, in association with A. Schwager, on the Nephelin-Basalt of Oberleinleiter; Dr. H. Thürach reviews the divisions of the Keuper in Northern Franconia as compared with those of adjoining areas; and Prof. v. Gümbel contributes some very interesting supplementary notes to the geology of the Bavarian Alps. In one of these he calls attention to the succession of Cretaceous beds in the Algäuer Alps, and mentions that an important deposit of green sandstone exposed on the border of the Illerthal, which had been regarded by Murchison in 1849 as a passage-bed between the Cretaceous and Eocene Nummulitic strata, had been proved, by the fossils lately discovered in it by Prof. v. Zittel, to belong to a distinct horizon of the Upper Chalk not hitherto known in the district. Gümbel also confirms the discovery, first made by Professor Penck, of the interglacial age of the beds of brown coal near Sonthofen, which have been deposited between two beds of boulder material with striated erratics. The coal is now extensively worked for fuel. A peculiar feature of some of the erratic boulders is that they are now completely hollow. They appear to have been originally of dolomite, and by the action of carbonated water the inner portions have been dissolved and removed, leaving only a hard surface crust.

Another interesting fact in connection with the Algäuer Alps is that certain crystalline schists exposed in the Rettenschwanger Thal, which have been hitherto regarded as of the age of the Bunter Sandstone, now prove to be Archæan, and indicate the existence of a ridge of these old rocks on the margin of the Alps.

Prof. Gümbel further points out that the springs of petroleum which have long been known on the western slopes of the Tegernsee are probably derived from dark bituminous shales, filled with fish remains, which occur in the Hauptdolomite. The shales are economically worked for asphalt at Seefeld, but the borings for oil at the Tegernsee have been unsuccessful, only small quantities having been met with. G. J. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 8, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "The Rocks of Alderney and the Casquets." By the Rev. Edwin Hill, M.A., F.G.S.

The author in this paper described Alderney, Burhou, with its surrounding reefs, and the remoter cluster of the Casquets, all included within an area about 10 miles long.

Alderney itself consists in most part of crystalline igneous rocks, hornblendic granites of varying constitution which resemble some Guernsey rocks, but seem more nearly connected with those of

Herm and Sark. These are pierced by various dykes, and among them by an intrusion containing olivine, which may be placed with the group of picrites. There is also in the island a dyke of mica-trap.

The eastern part only of Alderney, but the whole of Burhou, the Casquets and their neighbouring reefs, consist of stratified rocks. These contain rare beds of fine mudstone, but are generally false-bedded sandstones, and grits, sometimes with pebbles, often rather coarse and angular, occasionally becoming typical arkoses. At a point on the southern cliffs of Alderney they may be seen to rest on the crystalline igneous mass. A series identical in constitution and aspect occurs at Omonville, on the mainland, a few miles east of Cap La Hague (as had also been noticed a few months earlier by M. Bigot). These have been correlated with others near Cherbourg, and described as underlying the "grès Armoricain." The Alderney grits therefore form part of a series which can be traced over 30 miles, and which belongs to the Upper Cambrian (of Lapworth).

Remarks were made on the Jersey conglomerates (Ansted's conjectural identification of these with the Alderney grits being approved), on the resulting evidence that the Jersey rhyolites are not Permian, but Cambrian at the latest, on the still earlier age of the Guernsey syenites and diorites, and on the antiquity of the Guernsey gneisses.

2. "On the Ashprington Volcanic Series of South Devon." By the late Arthur Champernowne, Esq., M.A., F.G.S. Communicated by Dr. A. Geikie, F.R.S., F.G.S.

The author described the general characters of the volcanic rocks that occupy a considerable area of the country around Ashprington, near Totnes. They comprise tuffs and lavas, the latter being sometimes amygdaloidal and sometimes flaggy and aphanitic. The aphanitic rocks approach in character the porphyritic "schalsteins" of Nassau. Some of the rocks are much altered; the felspars are blurred, as if changing to saussurite, like the felspars in the Lizard gabbros. In other cases greenish aphanitic rocks have, by the decomposition of magnetite or ilmenite, become raddled and earthy in appearance, so as to resemble tuffs. The beds are clearly intercalated in the Devonian group of rocks, and the term Ashprington Series is applied to them by the author. Although this series probably contains some detrital beds, there are no true grits in it. Stratigraphically the series appears to come between the Great Devon Limestone and the Cockington Beds, the evidence being discussed by the author, however, not so fully as he had intended, as the paper was not completed.

II.—May 22, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "Notes on the Hornblende Schists and Banded Crystalline Rocks of the Lizard." By Major-Gen. C. A. McMahon, F.G.S.

The Lizard district has been visited by the author on three occasions during the years 1887–8–9, and the specimens of the

rocks collected were subjected to microscopic examination. After summarizing the work of previous writers, the author proceeded to consider the hornblende schists. He described these rocks and gave a table showing their constituent minerals. He noted the absence of quartz, the presence of pyroxene, and the fact that the minerals present are those commonly met with in volcanic rocks either as original minerals or as secondary products, and he considers that the microscopic study of the schists confirms the opinion of some previous writers that the schists had a volcanic origin and consisted principally of ash-beds. The absence of free quartz militates strongly against the supposition that they were originally sedimentary rocks of an ordinary character, whilst the fact of their being bedded shows that they are not plutonic. The author has found no evidence that the foliation of these rocks is due to dynamic deformation, and gives reasons for supposing that such was not the case. The rock seems to have been originally homogeneous, and its banding produced at a later stage by the segregation of the hornblende in planes parallel to the bedding.

The rocks furnish abundant evidence of the action of water, as shown by the presence of calcite, chlorite, steatite, and other products of aqueous action, as well as by channels fringed with magnetite, ferrite, or limonite. The action of water in converting augite into hornblende may be distinctly traced when the slices still contain pyroxene. The production of periodical currents of water through the water-bearing strata adjoining the roots of a volcano was commented on, and the author suggested that the banding of the hornblende schists was produced by such water leeching out unstable minerals, such as pyroxene, from the spaces between the planes of lamination, and the formation of comparatively stable minerals, such as hornblende, along those planes. The Lizard rocks contain good examples of the formation of hornblende in the wet way, that mineral having been deposited in cracks in such a way as to join together the ends of hornblende crystals severed by these cracks.

The "granulitic" group, of which the author gave a table showing the constituent minerals, was then described. Judged by their mineralogical contents the dark bands consist of diorite and the white bands of granite.

The author considers that portions of this group consist, like the hornblende schists, of converted ash-beds, but that other portions are composed of intrusive diorites of later date, the quasi-bedded appearance of both being due to the injection of granite. He pointed out that the quasi-banding is very irregular in its character, that the bands inosculate, bifurcate, and entangle themselves in complicated meshes inconsistent with the idea of regular banding, and that they are deflected by the blocks of serpentine imbedded in the dioritic portions of the granulitic rocks as well as by the porphyritic crystals of felspar contained in the latter. In certain places, as on the foreshore at Kennack Cove, the intrusive character of the granitic veins is undoubted, as they cut through the diorite in all directions, but they graduate into bands of normal

character. The author considers that the process of injection was aided by the plasticity of the "granulitic" beds induced by the neighbourhood of igneous masses; also in the case of sub-marine ash-beds by the planes of sedimentation; and in the case of intruded sheets of diorite, by the foliation parallel to the bedding, the intrusion of the granite being subsequent to that of the diorite.

At Pen Voose a foliated granite, the author pointed out, occurs in association with a non-foliated gabbro and diorite, a fact indicating in his opinion that the foliation of the granite was produced before its perfect consolidation. The granite was the last to appear in the order of time, and had the foliation of the granite been produced by pressure after cooling, the gabbro and diorite would also have been foliated.

2. "The Upper Jurassic Clays of Lincolnshire." By Thomas Roberts, Esq., M.A., F.G.S.

In Lincolnshire it has generally been considered that the Oxford and Kimeridge Clays come in direct sequence, and that the Corallian group of rocks is not represented. The author, however, endeavoured to show that there is between the Oxford and Kimeridge a zone of clay which is of Corallian age.

Six palæontological zones were recognized in the Oxford Clay. The clays which come between the Oxford and Upper Kimeridge the author divided into the following zones:—

(1) Black selenitiferous clays. (2) Dark clays crowded with *Ostrea deltoidea*. (3) Clays with *Ammonites alternans*; and (4) clays in which this fossil is absent.

The black selenitiferous Clays (1) are regarded as Corallian, because (*a*) They come between the Oxford Clay and the basement bed of the Kimeridge. (*b*) Out of the 23 species of fossils collected from this zone 22 are Corallian. (*c*) *Ostrea deltoidea* and *Gryphæa dilatata* occur together in these clays, and also in the Corallian, but in no other formation.

The zones 2, 3, and 4 are of Lower Kimeridge Clay age. The lowest zone (2) is very persistent in character, and is met with in Yorkshire, Cambridgeshire, Oxfordshire, and the South of England. The remaining zones (3 and 4) are local in their development.

3. "Origin of Movements in the Earth's Crust." By James R. Kilroe, Esq. Communicated by A. B. Wynne, Esq., F.G.S.

The author is convinced that a very important factor has been omitted from the usual explanation offered in accounting for the vast movements which have obtained in the earth's crust. His acknowledgments are due to Mr. Fisher for the extensive use made of his valuable work. He also refers frequently to the views and publications of other writers on terrestrial physics. From a somewhat conflicting mass of figures he concludes that about 20 miles would remain to represent the amount of radial contraction due to cooling during the period from Archæan to Recent times, corresponding to a circumferential contraction of 120 miles. This will have to be distributed over widely separate periods, at each of which there is abundant evidence of lateral compression.

But he considers that this shrinkage alone will not account for

all the plication or distortion of strata which constitute so important a factor in mountain-making, and he is disposed to supplement it in the way to which allusion has already been made by Mr. Wynne in a recent Presidential Address, viz. by considering the effects of the attenuation of strata under superincumbent pressure from deposition in subsiding areas, which involves the thickening, puckering, reduplication, and piling up of strata in regions where pressure has been lessened. It should be noted that, until disturbance of "cosmical equilibrium" takes place, mere pressure does not produce metamorphism. The extent of these lateral movements is described, and it is asserted that the theories hitherto adopted to account for plication, etc., are inadequate.

The origin of the horizontal movements is further discussed on the hypothesis that solids can flow after the manner of liquids, when they are subjected to sufficient pressure. He considers that the displacement in N.W. Scotland may have been *initiated* by the force due to contraction and accumulating in the crust throughout the periods marked by the deposition of Torridon Sandstone and Silurian stata, the elements of movement finding an exit at the ancient Silurian surface. In this case the pile of Silurian strata formerly covering the region now occupied by the North Sea and part of the Atlantic forced the lowest strata to move laterally, the protuberances of the underlying pre-Silurian rocks being also involved in the shearing process. Similar results occur in other mountain areas. The strata compressed have been greatly attenuated, and extended in proportion; in this way we may account for the piling up of strata by contortion in certain regions. The connexion of this interpretation with Malet's theory of volcanoes is also indicated, and the author concludes by applying these views to other branches of terrestrial physics.

CORRESPONDENCE.

FOLIATION IN THE MALVERN HILLS.

Sir,—I ask permission to make a brief explanation in reference to the debate on General Macmahon's memoir read before the Geological Society on May 22nd. The published summary of the discussion attributes to Mr. J. J. H. Teall the statement that, in a paper read at a previous meeting, "foliation was actually taken as evidence of deformation." The paper[1] here referred to was one read by me on April 17th. Taken without qualification, Mr. Teall's remark does not accurately express my views. Nothing is more certain than that foliation has been produced in more ways than one, and this I have repeatedly said and printed. In the Malvern Hills, however, I hold that foliation is always the result of deformation. This conclusion is not assumed, but is based upon the fact that, wherever the rock lying between an igneous mass and a schist is exposed, a gradation between the two can be traced, and the pro-

[1] See summary of it in Geol. Mag. for June, p. 285. The discussion of papers, is omitted from the Reports given in the Magazine from want of space.—Edit. G. M.

gressive deformation can be shown under the microscope. I have a right to say "wherever," because I do not think there is a single exposure of any magnitude in the entire chain which I have failed to examine, and the most critical sections I have visited repeatedly.

My paper of April 17th treated, not so much of the origin of the schists in question, as of the production of some of the constituent minerals. The evidence offered under the former head was accordingly very incomplete, and a great part of the debate seemed to me rather premature. I hope my critics will visit the Malvern region, and will favour me with their opinion when I read my paper on the main question.

CH. CALLAWAY.

WELLINGTON, *June 11th*, 1889.

OBITUARY

ROBERT DAMON, F.G.S.

BORN, 1814; DIED, 1889.

WE regret to record the death of MR. ROBERT DAMON, F.G.S., of No. 4, Pulteney, Weymouth, Dorset, the well-known Geologist and Naturalist, which occurred suddenly from heart-disease, on Saturday the 4th May. He was the author of an excellent work on "The Geology of Weymouth, and the Isle of Portland," and was a most extensive traveller and an assiduous collector. He procured a marvellous series of Cretaceous fossil Fishes from the Lebanon, Syria, now in the British Museum (Nat. Hist.), also the most complete example of the skeleton of that rare extinct Sirenian "Steller's Sea-cow," from Behring Island. Although in his 75th year, he contemplated an expedition to Siberia in order to obtain an entire Mammoth's skeleton for the National Museum. Mr. Damon frequently visited Moscow and St. Petersburg, and was a Corresponding Member of the Imperial Society of Natural History, Moscow, and of other learned bodies in various parts of the world. Only a few years since he took passage from Nijni Novgorod down the Volga to Astrakhan, where he made the first collection of the fishes of the Caspian Sea yet brought to this country.

He lately purchased the celebrated collections forming the "Museum Godeffroy" in Hamburg, together with the published catalogues of that museum prepared by various eminent naturalists.

In his native town of Weymouth, Mr. Damon exercised great influence for good amongst his fellow-townsmen, by whom he was greatly honoured and valued for the integrity and uprightness of his character, and his large-hearted sympathy with all cases of distress. His charities were performed without ostentation, and only the recipients ever knew the kind friend who helped them in their time of need. His loss will long be felt by a very wide circle of friends, in all parts of the world, by whom he was warmly esteemed and greatly respected. His son, Mr. R. F. Damon, now carries on his father's extensive Natural History Agency in Weymouth.

HENRY WILLIAM BRISTOW, F.R.S., F.G.S., late Director of the Geological Survey of England.—We have to announce the death on the 14th of June, of this eminent geologist, at the age of 72. Mr. Bristow had for some time past been an invalid. We hope to publish a notice of his scientific labours in the August number.